ATTACHMENT E

TREATMENT BMP DATASHEET

Settling Pond

BMP Volume and Flow Rate Calculations for Meadowood Vesting Tenataive Map

Settling Basins

Drainage Basin	Settling Basin Identifier	Tributary Area (Acres)	Weighted Runoff Coefficient	85% Rainfall (inches) ¹	Required Volume (Acre-feet)	Actual Volume (Acre-feet)	Is Volume Acceptable?
2000	DB2	51.0	0.34	0.85	1.2	1.2	YES
3000	DB3	61.6	0.39	0.85	1.7	4.0	YES
4000	DB4	11.2	0.50	0.85	0.4	1.2	YES
7000A	DB7A	194.5	0.49	0.85	6.8	20.0	YES
7000B	DB7B	45.3	0.41	0.85	1.3	4.0	YES
8000A	DB8A	26.8	0.56	0.85	1.1	1.9	YES
8000B	DB8B	26.1	0.55	0.85	1.0	2.8	YES

¹⁾ See Exhibit titled 85th Percentile Isopluvial Map for Meadowood

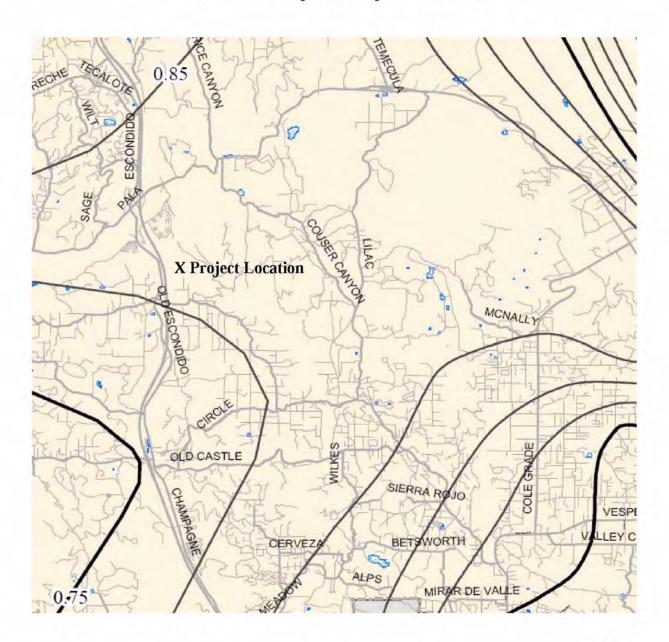
Rioclean Filter Inserts with BioMEDIA Green Filter (Horse Ranch Creek Road)

Inlet	Tributary Area (Acres) ²	Runoff Coefficient	Intensity (in/hr)	Treatment Q (cfs)	Bioclean Capacity (cfs)	Is Capacity Acceptable?
2000 (2012A)	1.5	0.9	0.2	0.3	0.47	YES
2000 (2012B)	1.4	0.9	0.2	0.3	0.47	YES
2000 (2018A)	0.2	0.9	0.2	0.0	0.47	YES
2000 (2018B)	0.6	0.9	0.2	0.1	0.47	YES
2000 (2019A)	0.3	0.9	0.2	0.1	0.47	YES
2000 (2019B)	0.2	0.9	0.2	0.0	0.47	YES
2000 (2022.5A) ³	0.2	0.9	0.2	0.0	0.47	YES
2000 (2022.5B) ³	1.6	0.9	0.2	0.3	0.47	YES
Inlet A	1.0	0.9	0.2	0.2	0.47	YES
Inlet B	0.8	0.9	0.2	0.1	0.47	YES

²⁾ See Exhibit titled Drainage Basins for Meadowood Bioclean withBioMEDIA Green Filter sizing

³⁾ Area that reaches Inlet 2022.5B does not include 0.3 Acres of Settling Basin

85th Percentile Isopluvial Map for Meadowood



J-15956 April 8, 2009



Design Considerations

- Tributary Area
- Area Required
- Hydraulic Head

Description

Dry extended detention ponds (a.k.a. dry ponds, extended detention basins, detention ponds, extended detention ponds) are basins whose outlets have been designed to detain the stormwater runoff from a water quality design storm for some minimum time (e.g., 48 hours) to allow particles and associated pollutants to settle. Unlike wet ponds, these facilities do not have a large permanent pool. They can also be used to provide flood control by including additional flood detention storage.

California Experience

Caltrans constructed and monitored 5 extended detention basins in southern California with design drain times of 72 hours. Four of the basins were earthen, less costly and had substantially better load reduction because of infiltration that occurred, than the concrete basin. The Caltrans study reaffirmed the flexibility and performance of this conventional technology. The small headloss and few siting constraints suggest that these devices are one of the most applicable technologies for stormwater treatment.

Advantages

- Due to the simplicity of design, extended detention basins are relatively easy and inexpensive to construct and operate.
- Extended detention basins can provide substantial capture of sediment and the toxics fraction associated with particulates.
- Widespread application with sufficient capture volume can provide significant control of channel erosion and enlargement caused by changes to flow frequency relationships resulting from the increase of impervious cover in a watershed.

Targeted Constituents

- Sediment
- Nutrients
- ✓ Trash

1

- Metals
- ✓ Bacteria
- ✓ Oil and Grease ▲
- ✓ Organics

Legend (Removal Effectiveness)

- Low High
- ▲ Medium



Limitations

- Limitation of the diameter of the orifice may not allow use of extended detention in watersheds of less than 5 acres (would require an orifice with a diameter of less than 0.5 inches that would be prone to clogging).
- Dry extended detention ponds have only moderate pollutant removal when compared to some other structural stormwater practices, and they are relatively ineffective at removing soluble pollutants.
- Although wet ponds can increase property values, dry ponds can actually detract from the value of a home due to the adverse aesthetics of dry, bare areas and inlet and outlet structures.

Design and Sizing Guidelines

- Capture volume determined by local requirements or sized to treat 85% of the annual runoff volume.
- Outlet designed to discharge the capture volume over a period of hours.
- Length to width ratio of at least 1.5:1 where feasible.
- Basin depths optimally range from 2 to 5 feet.
- Include energy dissipation in the inlet design to reduce resuspension of accumulated sediment.
- A maintenance ramp and perimeter access should be included in the design to facilitate access to the basin for maintenance activities and for vector surveillance and control.
- Use a draw down time of 48 hours in most areas of California. Draw down times in excess of 48 hours may result in vector breeding, and should be used only after coordination with local vector control authorities. Draw down times of less than 48 hours should be limited to BMP drainage areas with coarse soils that readily settle and to watersheds where warming may be determined to downstream fisheries.

Construction/Inspection Considerations

- Inspect facility after first large to storm to determine whether the desired residence time has been achieved.
- When constructed with small tributary area, orifice sizing is critical and inspection should verify that flow through additional openings such as bolt holes does not occur.

Performance

One objective of stormwater management practices can be to reduce the flood hazard associated with large storm events by reducing the peak flow associated with these storms. Dry extended detention basins can easily be designed for flood control, and this is actually the primary purpose of most detention ponds.

Dry extended detention basins provide moderate pollutant removal, provided that the recommended design features are incorporated. Although they can be effective at removing

some pollutants through settling, they are less effective at removing soluble pollutants because of the absence of a permanent pool. Several studies are available on the effectiveness of dry extended detention ponds including one recently concluded by Caltrans (2002).

The load reduction is greater than the concentration reduction because of the substantial infiltration that occurs. Although the infiltration of stormwater is clearly beneficial to surface receiving waters, there is the potential for groundwater contamination. Previous research on the effects of incidental infiltration on groundwater quality indicated that the risk of contamination is minimal.

There were substantial differences in the amount of infiltration that were observed in the earthen basins during the Caltrans study. On average, approximately 40 percent of the runoff entering the unlined basins infiltrated and was not discharged. The percentage ranged from a high of about 60 percent to a low of only about 8 percent for the different facilities. Climatic conditions and local water table elevation are likely the principal causes of this difference. The least infiltration occurred at a site located on the coast where humidity is higher and the basin invert is within a few meters of sea level. Conversely, the most infiltration occurred at a facility located well inland in Los Angeles County where the climate is much warmer and the humidity is less, resulting in lower soil moisture content in the basin floor at the beginning of storms.

Vegetated detention basins appear to have greater pollutant removal than concrete basins. In the Caltrans study, the concrete basin exported sediment and associated pollutants during a number of storms. Export was not as common in the earthen basins, where the vegetation appeared to help stabilize the retained sediment.

Siting Criteria

Dry extended detention ponds are among the most widely applicable stormwater management practices and are especially useful in retrofit situations where their low hydraulic head requirements allow them to be sited within the constraints of the existing storm drain system. In addition, many communities have detention basins designed for flood control. It is possible to modify these facilities to incorporate features that provide water quality treatment and/or channel protection. Although dry extended detention ponds can be applied rather broadly, designers need to ensure that they are feasible at the site in question. This section provides basic guidelines for siting dry extended detention ponds.

In general, dry extended detention ponds should be used on sites with a minimum area of 5 acres. With this size catchment area, the orifice size can be on the order of 0.5 inches. On smaller sites, it can be challenging to provide channel or water quality control because the orifice diameter at the outlet needed to control relatively small storms becomes very small and thus prone to clogging. In addition, it is generally more cost-effective to control larger drainage areas due to the economies of scale.

Extended detention basins can be used with almost all soils and geology, with minor design adjustments for regions of rapidly percolating soils such as sand. In these areas, extended detention ponds may need an impermeable liner to prevent ground water contamination.

The base of the extended detention facility should not intersect the water table. A permanently wet bottom may become a mosquito breeding ground. Research in Southwest Florida (Santana et al., 1994) demonstrated that intermittently flooded systems, such as dry extended detention

ponds, produce more mosquitoes than other pond systems, particularly when the facilities remained wet for more than 3 days following heavy rainfall.

A study in Prince George's County, Maryland, found that stormwater management practices can increase stream temperatures (Galli, 1990). Overall, dry extended detention ponds increased temperature by about 5°F. In cold water streams, dry ponds should be designed to detain stormwater for a relatively short time (i.e., 24 hours) to minimize the amount of warming that occurs in the basin.

Additional Design Guidelines

In order to enhance the effectiveness of extended detention basins, the dimensions of the basin must be sized appropriately. Merely providing the required storage volume will not ensure maximum constituent removal. By effectively configuring the basin, the designer will create a long flow path, promote the establishment of low velocities, and avoid having stagnant areas of the basin. To promote settling and to attain an appealing environment, the design of the basin should consider the length to width ratio, cross-sectional areas, basin slopes and pond configuration, and aesthetics (Young et al., 1996).

Energy dissipation structures should be included for the basin inlet to prevent resuspension of accumulated sediment. The use of stilling basins for this purpose should be avoided because the standing water provides a breeding area for mosquitoes.

Extended detention facilities should be sized to completely capture the water quality volume. A micropool is often recommended for inclusion in the design and one is shown in the schematic diagram. These small permanent pools greatly increase the potential for mosquito breeding and complicate maintenance activities; consequently, they are not recommended for use in California.

A large aspect ratio may improve the performance of detention basins; consequently, the outlets should be placed to maximize the flowpath through the facility. The ratio of flowpath length to

width from the inlet to the outlet should be at least 1.5:1 (L:W) where feasible. Basin depths optimally range from 2 to 5 feet.

The facility's drawdown time should be regulated by an orifice or weir. In general, the outflow structure should have a trash rack or other acceptable means of preventing clogging at the entrance to the outflow pipes. The outlet design implemented by Caltrans in the facilities constructed in San Diego County used an outlet riser with orifices sized to discharge the water quality volume, and the riser

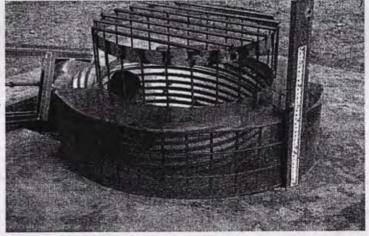


Figure 1
Example of Extended Detention Outlet Structure

overflow height was set to the design storm elevation. A stainless steel screen was placed

around the outlet riser to ensure that the orifices would not become clogged with debris. Sites either used a separate riser or broad crested weir for overflow of runoff for the 25 and greater year storms. A picture of a typical outlet is presented in Figure 1.

The outflow structure should be sized to allow for complete drawdown of the water quality volume in 72 hours. No more than 50% of the water quality volume should drain from the facility within the first 24 hours. The outflow structure can be fitted with a valve so that discharge from the basin can be halted in case of an accidental spill in the watershed.

Summary of Design Recommendations

(1) Facility Sizing - The required water quality volume is determined by local regulations or the basin should be sized to capture and treat 85% of the annual runoff volume. See Section 5.5.1 of the handbook for a discussion of volume-based design.

Basin Configuration — A high aspect ratio may improve the performance of detention basins; consequently, the outlets should be placed to maximize the flowpath through the facility. The ratio of flowpath length to width from the inlet to the outlet should be at least 1.5:1 (L:W). The flowpath length is defined as the distance from the inlet to the outlet as measured at the surface. The width is defined as the mean width of the basin. Basin depths optimally range from 2 to 5 feet. The basin may include a sediment forebay to provide the opportunity for larger particles to settle out.

A micropool should not be incorporated in the design because of vector concerns. For online facilities, the principal and emergency spillways must be sized to provide 1.0 foot of freeboard during the 25-year event and to safely pass the flow from 100-year storm.

- (2) Pond Side Slopes Side slopes of the pond should be 3:1 (H:V) or flatter for grass stabilized slopes. Slopes steeper than 3:1 (H:V) must be stabilized with an appropriate slope stabilization practice.
- (3) Basin Lining Basins must be constructed to prevent possible contamination of groundwater below the facility.
- (4) Basin Inlet Energy dissipation is required at the basin inlet to reduce resuspension of accumulated sediment and to reduce the tendency for short-circuiting.
- (5) Outflow Structure The facility's drawdown time should be regulated by a gate valve or orifice plate. In general, the outflow structure should have a trash rack or other acceptable means of preventing clogging at the entrance to the outflow pipes.

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The outflow structure should be sized to allow for complete drawdown of the water quality volume in 72 hours. No more than 50% of the water quality volume should drain from the facility within the first 24 hours. The outflow structure should be fitted with a valve so that discharge from the basin can be halted in case of an accidental spill in the watershed. This same valve also can be used to regulate the rate of discharge from the basin.

The discharge through a control orifice is calculated from:

 $Q = CA(2gH-H_0)^{0.5}$

where: $Q = discharge (ft^3/s)$

C = orifice coefficient A = area of the orifice (ft²)

g = gravitational constant (32.2) H = water surface elevation (ft)

Ho= orifice elevation (ft)

Recommended values for C are 0.66 for thin materials and 0.80 when the material is thicker than the orifice diameter. This equation can be implemented in spreadsheet form with the pond stage/volume relationship to calculate drain time. To do this, use the initial height of the water above the orifice for the water quality volume. Calculate the discharge and assume that it remains constant for approximately 10 minutes. Based on that discharge, estimate the total discharge during that interval and the new elevation based on the stage volume relationship. Continue to iterate until H is approximately equal to H_o. When using multiple orifices the discharge from each is summed.

- (6) Splitter Box When the pond is designed as an offline facility, a splitter structure is used to isolate the water quality volume. The splitter box, or other flow diverting approach, should be designed to convey the 25-year storm event while providing at least 1.0 foot of freeboard along pond side slopes.
- (7) Erosion Protection at the Outfall For online facilities, special consideration should be given to the facility's outfall location. Flared pipe end sections that discharge at or near the stream invert are preferred. The channel immediately below the pond outfall should be modified to conform to natural dimensions, and lined with large stone riprap placed over filter cloth. Energy dissipation may be required to reduce flow velocities from the primary spillway to non-erosive velocities.
- (8) Safety Considerations Safety is provided either by fencing of the facility or by managing the contours of the pond to eliminate dropoffs and other hazards. Earthen side slopes should not exceed 3:1 (H:V) and should terminate on a flat safety bench area. Landscaping can be used to impede access to the facility. The primary spillway opening must not permit access by small children. Outfall pipes above 48 inches in diameter should be fenced.

Maintenance

Routine maintenance activity is often thought to consist mostly of sediment and trash and debris removal; however, these activities often constitute only a small fraction of the maintenance hours. During a recent study by Caltrans, 72 hours of maintenance was performed annually, but only a little over 7 hours was spent on sediment and trash removal. The largest recurring activity was vegetation management, routine mowing. The largest absolute number of hours was associated with vector control because of mosquito breeding that occurred in the stilling basins (example of standing water to be avoided) installed as energy dissipaters. In most cases, basic housekeeping practices such as removal of debris accumulations and vegetation management to ensure that the basin dewaters completely in 48-72 hours is sufficient to prevent creating mosquito and other vector habitats.

Consequently, maintenance costs should be estimated based primarily on the mowing frequency and the time required. Mowing should be done at least annually to avoid establishment of woody vegetation, but may need to be performed much more frequently if aesthetics are an important consideration.

Typical activities and frequencies include:

- Schedule semiannual inspection for the beginning and end of the wet season for standing water, slope stability, sediment accumulation, trash and debris, and presence of burrows.
- Remove accumulated trash and debris in the basin and around the riser pipe during the semiannual inspections. The frequency of this activity may be altered to meet specific site conditions.
- Trim vegetation at the beginning and end of the wet season and inspect monthly to prevent establishment of woody vegetation and for aesthetic and vector reasons.
- Remove accumulated sediment and regrade about every 10 years or when the accumulated sediment volume exceeds 10 percent of the basin volume. Inspect the basin each year for accumulated sediment volume.

Cost

Construction Cost

The construction costs associated with extended detention basins vary considerably. One recent study evaluated the cost of all pond systems (Brown and Schueler, 1997). Adjusting for inflation, the cost of dry extended detention ponds can be estimated with the equation:

 $C = 12.4V^{0.760}$

where:

C = Construction, design, and permitting cost, and

 $V = Volume (ft^3).$

Using this equation, typical construction costs are:

\$ 41,600 for a 1 acre-foot pond

\$ 239,000 for a 10 acre-foot pond

\$ 1,380,000 for a 100 acre-foot pond

Interestingly, these costs are generally slightly higher than the predicted cost of wet ponds (according to Brown and Schueler, 1997) on a cost per total volume basis, which highlights the difficulty of developing reasonably accurate construction estimates. In addition, a typical facility constructed by Caltrans cost about \$160,000 with a capture volume of only 0.3 ac-ft.

An economic concern associated with dry ponds is that they might detract slightly from the value of adjacent properties. One study found that dry ponds can actually detract from the perceived value of homes adjacent to a dry pond by between 3 and 10 percent (Emmerling-Dinovo, 1995).

Maintenance Cost

For ponds, the annual cost of routine maintenance is typically estimated at about 3 to 5 percent of the construction cost (EPA website). Alternatively, a community can estimate the cost of the maintenance activities outlined in the maintenance section. Table 1 presents the maintenance costs estimated by Caltrans based on their experience with five basins located in southern California. Again, it should be emphasized that the vast majority of hours are related to vegetation management (mowing).

Table 1	Estimated Average Ann	ual Maintenance Eff	ort
Activity	Labor Hours	Equipment & Material (\$)	Cost
Inspections	4	7	183
Maintenance	49	126	2282
Vector Control	o	o	О
Administration	3	o	132
Materials	-	535	535
Total	56	\$668	\$3,132

References and Sources of Additional Information

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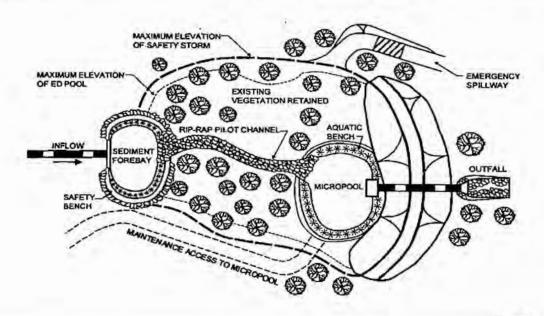
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Information Resources

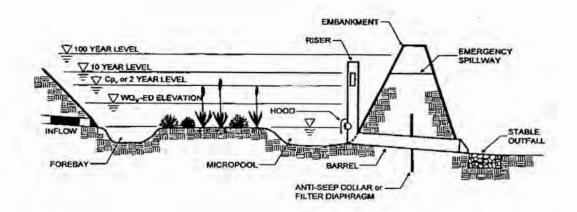
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PLAN VIEW



PROFILE

Schematic of an Extended Detention Basin (MDE, 2000)

BioClean Inlet Filter Insert with a BioMEDIA Green Filter (Onsite)

BMP Volume and Flow Rate Calculations for Meadowood Vesting Tenataive Map

Settling Basins

Settling Dasins							
Drainage Basin	Settling Basin	Tributary Area	Weighted Runoff	85% Rainfall	Required Volume	Actual Volume	Is Volume Acceptable?
	Identifier	(Acres)	Coefficient	(inches)1	(Acre-feet)	(Acre-feet)	Acceptable:
2000	DB2	51.0	0.34	0.85	1.2	1.2	YES
3000	DB3	61.6	0.39	0.85	1.7	4.0	YES
4000	DB4	11.2	0.50	0.85	0.4	1.2	YES
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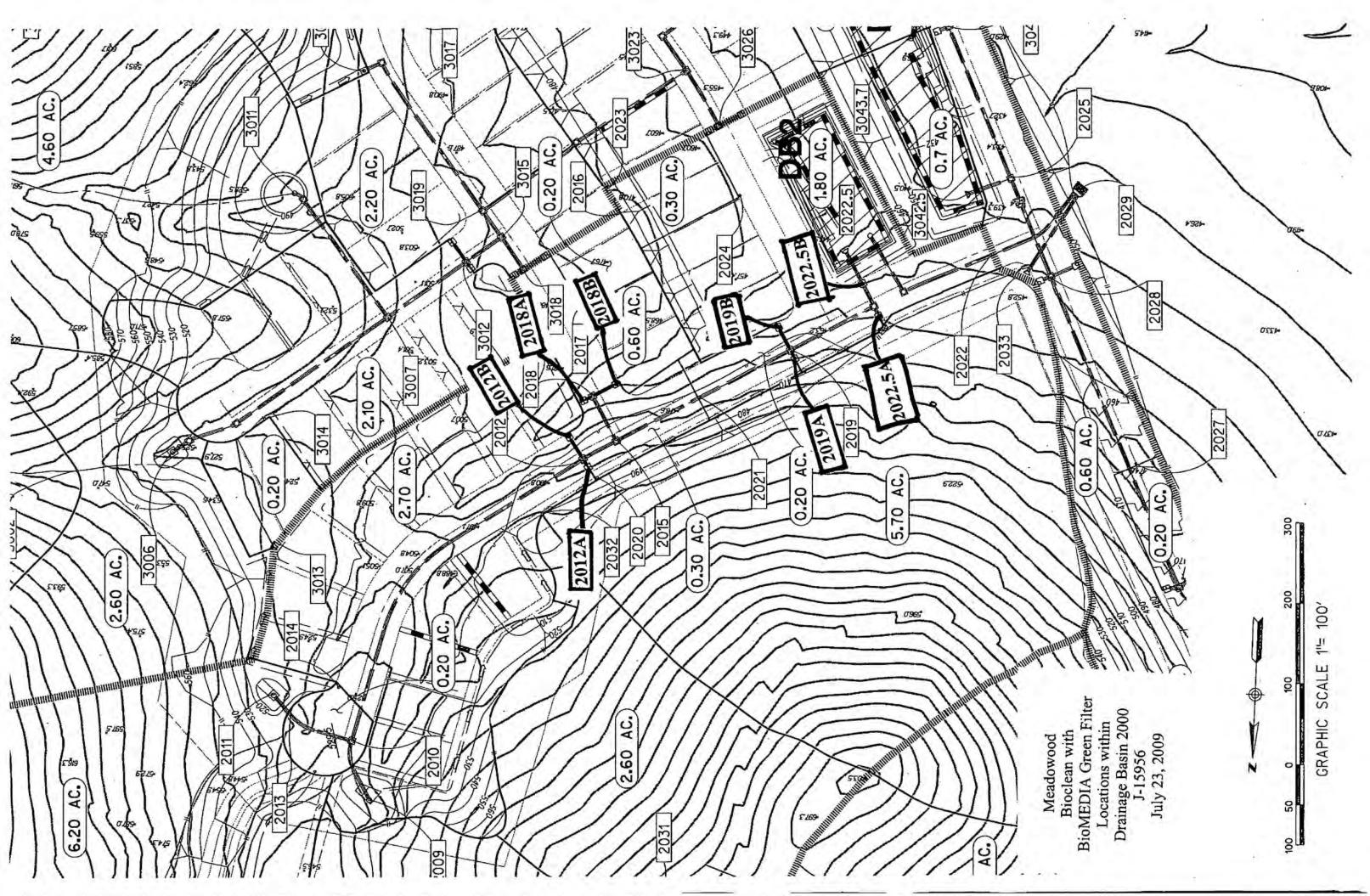
¹⁾ See Exhibit titled 85th Percentile Isopluvial Map for Meadowood

Bioclean Filter Inserts with BioMEDIA Green Filter (Horse Ranch Creek Road)

Bioclean Filter miserts with Biomedia ofeen Filter (Horse Randh ofeek Rose)						
Inlet	Tributary Area	Runoff Coefficient	Intensity	Treatment	Bioclean Capacity	Is Capacity Acceptable?
	(Acres)2		(in/hr)	(cfs)	(cfs)	
2000 (2012A)	1.5	0.9	0.2	0.3	0.47	YES
2000 (2012B)	1.4	0.9	0.2	0.3	0.47	YES
2000 (2018A)	0.2	0.9	0.2	0.0	0.47	YES
2000 (2018B)	0.6	0.9	0.2	0.1	0.47	YES
2000 (2019A)	0.3	0.9	0.2	0.1	0.47	YES
2000 (2019B)	0.2	0.9	0.2	0.0	0.47	YES
2000 (2022.5A) ³	0.2	0.9	0.2	0.0	0.47	YES
2000 (2022.5B) ³	1.6	0.9	0.2	0.3	0.47	YES
Inlet A	1.0	0.9	0.2	0.2	0.47	YES
Inlet B	0.8	0.9	0.2	0.1	0.47	YE\$

²⁾ See Exhibit titled Drainage Basins for Meadowood Bioclean withBioMEDIA Green Filter sizing

³⁾ Area that reaches Inlet 2022.5B does not include 0.3 Acres of Settling Basin



CALIFORNIA MEDIA CURB INLET BASKET WATER CLEANSING SYSTEM SAN DIEGO REGIONAL STANDARD CURB INLET

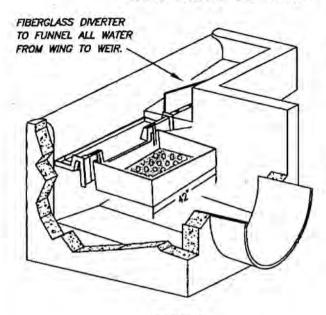


FIGURE 1 DETAIL OF PARTS

REMOVABLE BASKET CATCHES EVERYTHING AND MAY BE REMOVED THROUGH MANHOLE WITHOUT ENTRY.

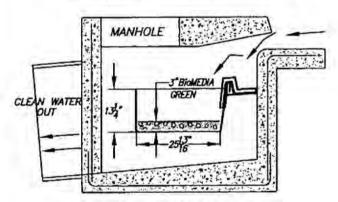


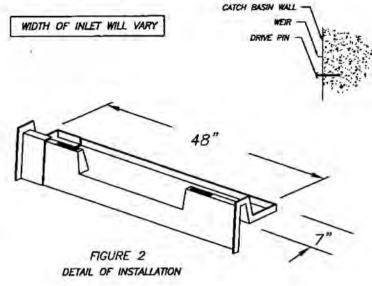
FIGURE 3
DETAIL OF PROCESS

BOX MANUFACTURED FROM MARINE GRADE FIBERGLASS & GEL COATED FOR UV PROTECTION

5 YEAR MANUFACTURERS WARRANTY

PATENTED

ALL FILTER SCREENS ARE STAINLESS STEEL



FLO	W RATE	S per Bask	et	
Q=S0*cd*/	4 \ 2*g*1	cd=	Control of an	.67
	so	A(ft ²)	h (in)	Q (3)
BioModiaGREEN		7.525	2.875	0.473

The above flow rates are based on unobstructed screens.

NOTES:

- 1.WEIR PROVIDES FOR ENTIRE COVERAGE
 OF INLET OPENING SO TO DIVERT ALL FLOW TO BASKET.
 2.WEIR MANUFACTURED FROM MARINE GRADE
 FIBERGLASS, GEL COATED FOR UV PROTECTION.
 3.WEIR ATTACHED TO THE CATCH BASIN WITH
- NON-CORROSIVE HARDWARE. 4.FILTRATION BASKET STRUCTURE MANUFACTURED OF MARINE GRADE FIBERGLASS,GEL COATED FOR UV
- PROTECTION.
 5.FILTRATION BASKET CONTAINS 3" THICK BIOMEDIA GREEN.

BIOMAGOGREEN THIRD PARTY TESTED REMOVAL EFFICIENCIES

TH (HTOROGENES) - MT - Man Committee (Co-Co-10) (Co-Co-

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	PROJECTS	
	ACHIENNE	BATTO .
4		BATE
CURB INLET BASKET SYSTEM	-	Series .
DATE: 01/20/09 SCALE:SF - 15	Avenue	DATES
DRAFTER: D.R.F. UNITS -INCHES	-	SATIO .

Hydraulic-Conductivity Flow Calculator

Calculates vertically downward flow rates given hydraulic conductivity, media thickness, and water head.

Enter the Hydraulic Conductivity (k) of Value accepted.	f the Filter Material:	1190	ft/day
2. Select the Units for the Hydraulic Con (Enter "M" for Metric or "E" for E		Selection accep	English ted.
Hydraulic-Conductivity Conversions	Meters per Day:	363	m/day
	Meters per Hour:	15.1	m/hr
	Meters per Minute;	0.252	m/min
	Meters per Second:	0.0042	m/s
j	Feet per Day:	1,190	ft/day
	Feet per Hour.	49.6	ft/hr
	Feet per Minute:	0.826	ft/min
	Feet per Second:	0.0138	ft/s
Enter the Thickness of the Filter Media Value accepted.	a in inches:	2.875	inches
 Enter the Water Depth above the Medi Value accepted. 	a Surface:	10.25	inches
Enter the Horizontal Surface Area in se Value accepted.	quare feet:	7.525	sqft
Calculated Flow Rates	Gallons per Minute:	212	gpm
	Cubic Feet per Second:	0.473	cfs
Optional Reynolds Number Check (Verific	es Darcian Flow)		
Enter the D30 representative grain diame Value accepted.	eter for the porous media:	20	um
Calculated Reynolds Number (Should be les	ss than approximately 10):	0.045	

Notes:

- 1. Values of hydraulic conductivity greater than 10,000 meters per day (and the equivalent in feet per day) will provide a warning that flow may be exceeding Darcian flow. This warning has no effect on calculator operation. Accordingly, check the Reynolds Number using the provided option.
- Values of filter media thickness and water depth above media greater than 100 inches will provide a warning. As with several other warnings, this warning was provided to identify a possible incorrect value entry and does not affect the calculator operation.
- Values of horizontal surface area that are greater than 10,000 square feet will provide a warning. Again, as with the other warnings, the warning was provided to identify possible incorrect value entries and does not affect calculator operation.
- The D30 representative grain diameter (often stated d₃₀) is the grain diameter that allows 30 percent passing as determined by performing a sieve analysis.

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Installation & Maintenance - BioMediaGREEN

I. Installation

Installation: The BioMediaGREEN filter blocks will be securely installed in the filter device, with contact surfaces sufficiently joined together so that no filter bypass can occur at low flow.

Installation Notes:

- Modular Wetland Systems. Inc, Inc. BioMediaGREEN filter blocks shall be installed pursuant to the manufacturer's recommendations and the details on this sheet.
- BioMediaGREEN filter blocks shall provide coverage of the incoming stormwater at the specified flow rate, based upon application and the device in which the boom is used in.
- BioMediaGREEN filter blocks are installed by removing the old block and replacing it with a new block.

II. Maintenance

Maintenance: The BioMediaGREEN filter block is made to be used for period that is determined by the amount of pollutant loading present in each installation. The filter blocks are easily removable from most filer devices. At each cleaning, new blocks should be installed by placing in the filter if deemed necessary by service crews.

Maintenance Notes:

- Modular Wetland Systems. Inc, recommends cleaning and debris removal maintenance a minimum of four times per year, and replacement of BioMediaGREEN filter blocks a minimum of once per year.
- Following maintenance and/or inspection, the maintenance operator shall prepare a maintenance/inspection record. The record shall include any maintenance activities performed, amount and description of debris collected, and condition of filter.
- The owner shall retain the maintenance/inspection record for a minimum of five years from the date of maintenance. These records shall be made available to the governing municipality for inspection upon request at any time.

Modular Wetland System, Inc.

Phone: 760-433-7640

www.modularwetlands.com Fax: 760-433-3176

- 4. For maintenance and cleaning remove old block and replace with new block. Where possible the maintenance should be performed from the ground surface. Note: entry into an underground stormwater vault such as an inlet vault requires certification in confined space training.
- Remove all trash, debris, organics, and sediments collected by the filter prior to removal and replacement of the BioMediaGREEN filter blocks.
- Evaluation of the BioMediaGREEN filter blocks shall be performed at each cleaning. If the block is filled with pollutants it should be replaced. The color of the block material is the best indication of the amount of pollutants present in the BioMediaGREEN material.
- Transport all debris, trash, organics and sediments to approved facility for disposal in accordance with local and state requirements.
- 8. The BioMediaGREEN filter blocks may be classified as hazardous material if it has absorbed large amounts of toxic substances and will have to be picked up and disposed of as hazardous waste. Hazardous material can only be handled by a certified hazardous waste trained person (minimum 24-hour hazwoper).

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OPERATION & MAINTEANCE Curb Inlet Basket

Maintenance

Maintenance: The filter is designed to allow for the use of vacuum removal of captured materials in the filter basket, serviceable by centrifugal compressor vacuum units without causing damage to the filter or any part of the mounting and attachment hardware during normal cleaning and maintenance. Filters can be cleaned and vacuumed from the manhole-opening and not from the curb opening. All filters not accessible from the manhole will be rejected.

Maintenance Notes:

- Bio Clean Environmental Services, Inc. recommends cleaning and debris removal
 maintenance a minimum of four times per year, and replacement of hydrocarbon booms a
 minimum of twice per year.
- Following maintenance and/or inspection, the maintenance operator shall prepare a maintenance/inspection record. The record shall include any maintenance activities performed, amount and description of debris collected, and condition of filter.
- The owner shall retain the maintenance/inspection record for a minimum of five years from the date of maintenance. These records shall be made available to the governing municipality for inspection upon request at any time.
- Any person performing maintenance activities must have comply with local state and city requirements.
- 5. Remove manhole lid to gain access to inlet filter insert. Filter basket should be located directly under the manhole lid. Where possible the maintenance should be performed from the ground surface. Note: entry into an underground stormwater vault such as an inlet vault requires certification in confined space training.
- 6. Remove all trash, debris, organics, and sediments collected by the inlet filter insert basket.
- Any debris located on the shelf system can be either removed from the shelf or can be pushed into the basket and retrieved from basket.
- Evaluation of the hydrocarbon boom shall be performed at each cleaning. If the boom is filled
 with hydrocarbons and oils it should be replaced. Removed boom by cutting plastic ties and
 remove boom. Attach new boom to basket with plastic ties through pre-drilled holes in
 basket
- 9. Place manhole lid back on manhole opening.
- Transport all debris, trash, organics and sediments to approved facility for disposal in accordance with local and state requirements.
- 11. The hydrocarbon boom shall be disposed according to local state and city requirements.



P O Box 869, Oceanside, CA 92049 (760 433-7640 Fax (760) 433-3176 www.biocleanenvironmental.net



Modular Wetland Systems, Inc. BioMediaGREEN Performance Testing

Prepared for

Modular Wetland Systems, Inc.

August 2007

Prepared By

Waves Environmental

P.O. Box 462290 Escondido, CA 92046-2290 Phone: 760-743-6720

www.wavesenv.com

Testing Laboratory

D-Tek Analytical Laboratories, Inc.

9020 Kenamar Drive, Suite 205 San Diego, CA 92121

Phone: 858-566-4542

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Reference: Pollutant Removal Testing

BioMediaGREEN Stormwater Filtration Media.

Waves Environmental is pleased to submit this report to Modular Wetland Systems, Inc. This report includes the laboratory analysis and photo documentation of testing procedures. The conclusions and recommendations are not part of this report since they are not part of the scope of work with Waves Environmental.

Scope of Work

Waves Environmental measured the percentage removal of various pollutants and TSS (Total Suspended Solids) retained/captured by BioMediaGREEN stormwater filtration media. The laboratory testing was accomplished by a specially designed flume to control flow and head through the filtration media. The dimensions of the media were 2.0 ft. wide by 0.5 ft. high and 0.25 ft. thick for a treatment surface area of approximately 1.00 sq. ft. The pollutants consisted of dissolved metals, dissolved nutrients, TSS, oil & grease, and TPH (Total Petroleum Hydrocarbons) and were provided by D-Tek Analytical Laboratories in a pre-mixed batch. This pre-mixed batch was mixed into a larger quantity of water to obtain a solution of contaminated water. A Sil-Co-Sil 106 Ground Silica was used to represent a fine TSS. Numerous grab samples were taken from the influent and effluent ends of the test unit. Grab samples were taken to the lab for analysis. A summary of the resulting data is presented in the report.

Description of Testing Apparatus

The flume was placed on an adjustable platform to allow for an appropriate amount of head, simulating conditions found in the field. A 2.0 ft. wide slab of BioMediaGREEN was placed inside the flume. A 500 gallon water truck was used to discharge the contaminated water through a 2" valve into the flume at a rate of 70 to 90 gpm. Flow through the media was anticipated to be between 2 and 5 gpm once a maximum head of 0.5 ft. was reached.

Test Set Up

The test was designed to simulate the pollution that occurs during a rainfall event to measure the effectiveness of BioMediaGREEN. Michael Alberson a CPESC, CPSWQ and REA from Waves Environmental performed the testing, measurements, and pollutant sampling. A specially designed flume was constructed and lined with rubber to provide a clean and uncontaminated surface to perform the testing.

The contaminated water was created by mixing a concentrated solution of the pre-mixed batch with 500 gallons of water. The pre-mix batch was put together by Mr. Alberson and D-Tek laboratories and contained the following pollutants, Nitrate or TKN, Oil & Grease, Ortho Phosphorus, Total Phosphorus, TSS, Cadmium, Copper, Lead, Nickel, Silver,

Zinc, and Mercury. This solution was added to the 500 gallon water tank and agitated with a mixer for a period of 15 minutes before and throughout the test period. Once mixed thoroughly a grab sample was taken form the tank influent (log -07-2698, 07-3828). These samples provided the influent levels of the polluted water to be compared with seven tests of effluent levels after treatment through the filtration media.

Testing Procedure

A flow meter and control valve regulated the flow between 2 to 5 gpm. Each test was conducted for approximately 1.25 minutes. Three grab samples of effluent water were used to get an average sample concentration. The sampling procedure of the effluent water is as follows: The contaminated water was allowed to flow through the filter for 30 seconds then one third of the effluent (treated) water was collected and poured into the sampling bottle. The second and third samples of treated water were taken after one minute and 1.5 minutes, respectively, and added to the sampling bottle.

It was observed that the visible hydrocarbons (a rainbow sheen floating on the surface) were present in the influent (before the BioMediaGREEN) and were not visible after leaving the backside (effluent), which indicated that the hydrocarbons were being absorbed by the media. The water collected in the downstream of the filter media was surprisingly clear and turbidity readings where very low.

As part of the initial sample of the influent readings where taken for pH, NTU and temperature. This initial information is as follows: time of testing started at 11:41 AM, wind was between 0.0-0.9 mph, temperature 79.4 degrees F, Barometric pressure 1011.0 hPa, starting pH = 8.73 and NTU= 39.1, altitude = 60 feet MSL.

Results

BioMediaGREEN Day 1

Run	Pollutant	Influent (mg/L)	Effluent (mg/L)	Percent Reduction
1-	Nitrate-N	5.43	5.38	0.92%
	Oil & Grease	360	11	96.94%
	Total Phosphorus			n/d – effluent sample contaminated
	TSS	73	17	76.71%
1	Cadmium	0.584	0.48	17.81%
	Copper	0.951	0.34	64.25%
	Lead	0.201	0.015	92.54%
1.5	Nickel	0.642	0.599	6.70%
	Silver	0.04	0.01	75.00%
	Zinc	1.33	0.93	30.08%
	Mercury	0.009	0.002	77.78%
2 -	ACCUPATE NO	4.87	5.15	-5.75%
2-	Nitrate-N			
	Oil & Grease	67	1	98.51%
	Total Phosphorus	3.81	0.46	87.93%
	TSS	52	15	71.15%
71	Cadmium	0.503	0.01	98.01%
	Copper	0.906	0.009	99.01%
	Lead	0.192	0.005	97.40%
	Nickel	0.582	0.196	66.32%
	Silver	0.04	0.01	75.00%
	Zinc	1.32	0.05	96.21%
	Mercury	0.006	0,002	66.67%
3 -	Nitrate-N	4.87	5.43	-11.50%
	Oil & Grease	67	1	98.51%
	Total Phosphorus	3.81	0.39	89.76%
-	TSS	52	13	75.00%
	Cadmium	0.503	0.006	98.81%
	Copper	0.906	0.005	99.45%
	Lead	0.192	0.005	97.40%
	Nickel	0.582	0.18	69.07%
	Silver	0.04	0.01	75.00%
	Zinc	1.32	0.05	96.21%
	Mercury	0.006	0.002	66.67%

n/d = non determinable

BioMediaGREEN Day 2

Run	Pollutant	Influent (mg/L)	Effluent (mg/L)	Percent Reduction
4-	TKN	10.4	8.29	20.29%
	Oil & Grease	13	7	46.15%
	Ortho Phosphorus	3.98	3.13	21.3%
	Total Phosphorus	1.37	.68	50.3%
	TSS	100	3	97.00%
	Cadmium	0.302	0.192	36.42%
	Copper	0.354	0.115	67.51%
	Lead	0.492	0.008	98.37%
	Nickel	0.52	0.46	11.54%
	Zinc	0.4	0.06	85.00%
	TPH	1.4	0 .	100.00%
		-		-77
5-	TKN	10.4	8.64	16.92%
	Oil & Grease	13	3	76.92%
	Ortho Phosphorus	3.98	2.15	45.9%
	Total Phosphorus	1.37	.75	45.2%
	TSS	100	5	95.00%
	Cadmium	0.302	0.193	36.09%
	Copper	0.354	0.119	66.38%
	Lead	0.492	0.007	98.58%
	Nickel	0.52	0.48	7.69%
	Zinc	0.4	0.06	. 85.00%
	TPH	1.4	0	100.00%
6-	TKN	10.4	10.9	-4.81%
	Oil & Grease	13	7	46.15%
	Ortho Phosphorus	3.98	2.2	44.7%
	Total Phosphorus	. 1.37	72	47.4%
	TSS	100	1	99.00%
	Cadmium	0.302	0.206	31.79%
	Copper	0.354	0.13	63.28%
	Lead	0.492	0.005	98.98%
	Nickel	0.52	0.5	3.85%
	Zinc	0.4	0.05	. 87.50%
	TPH	1.4	0	100.00%
7-	TKN	10.4	10.1	2.88%
	Oil & Grease	13	10	23.08%
	Ortho Phosphorus	3.98	2.11	46.9%
	Total Phosphorus	1.37	.69	49.6%
	TSS	100	6	94.00%

1	Cadmium	0.302	0.203	32.78%
	Copper	0.354	0.11	68.93%
	Lead	0.492	0.005	98.98%
	Nickel	0.52	0.53	-1.92%
	Zinc	0.4	0.05	87.50%
	TPH	1.4	0	100.00%
8-	· TKN	10.4	7.4	28.85%
	Oil & Grease	13	12	7.69%
	Ortho Phosphorus	3.98	2.04	48.7%
	Total Phosphorus	1.37	.7	48.9%
	TSS	100	2	98.00%
	Cadmium	0.302	0.193	36.09%
	Copper	0.354	0.117	66.95%
	Lead	0.492	0.005	98.98%
	Nickel	0.52	0.47	9.62%
	Zinc	0.4	0.05	87.50%
	TPH	1.4	0	100.00%

Summary of Results

Summary

Percent Reduction	Effluent (mg/L)	Influent (mg/L)	Pollutant
12.7%	9.07	10.4	TKN
90.7%	6.5	69.8	Oil & Grease
41.6%	2.33	3.98	Ortho Phosphorus
69.7%	.63	2.07	Total Phosphorus
85.4%	12.4	84.63	TSS
52.2%	0.19	0.39	Cadmium
79.2%	0.12	0.57	Copper
98.2%	0.01	0.38	Lead
22.5%	0.43	0.55	Nickel
78.2%	0.16	0.75	Zinc
100.00%	. 0	1.4	TPH

Summary

A total of eight runs where performed to provide verifiable removal efficiencies. After four 1.25 minute runs through the BioMediaGREEN stormwater filter media the effluent concentrations coming out of the system where analyzed and compared to influent concentrations. An influent concentration was sampled at the influent end of the system, prior to entering the systems filter processes. The BioMediaGREEN filter media demonstrated substantial reductions in the concentrations of various pollutants. Following is a summary of the effluent concentrations and resulting removal efficiencies.

There was an average effluent concentration of 6.5 mg/L for oil and grease, 0 mg/l for TPH (total petroleum hydrocarbons), resulting in an average removal efficiency of 90.7% and 100% respectively.

There was an average effluent concentration of 12.4 mg/L for TSS (mean particle size of 19 microns), .32 NTU for turbidity, resulting in an average removal efficiency of 85.4% and 99.1% respectively.

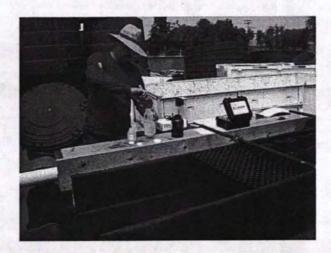
Removal of dissolved heavy metals varied. Copper, Lead, and Zinc are seen as big three in terms of adverse affects on water quality. There was an average effluent concentration of .12 mg/L for Copper, less than .01 mg/L for Lead, and .16 mg/L for Zinc resulting in an average removal efficiency of 79.2%, 98.2%, and 78.2% respectively.

Removal of nutrients varied among test runs. There was an average effluent concentration of .63 mg/L for Total Phosphorus and 9.07 mg/L for total kjeldahl nitrogen resulting in an average removal efficiency of 69.7% and 12.7% respectively.

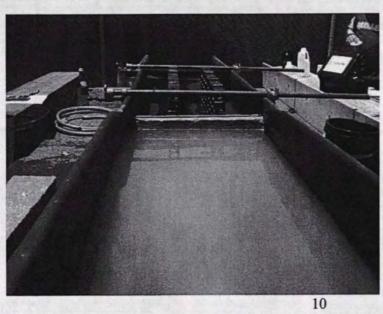
Appendix A

Testing Photos

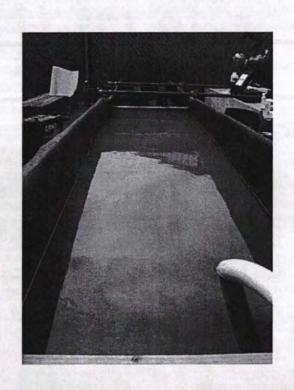


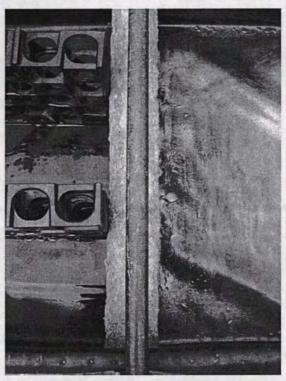


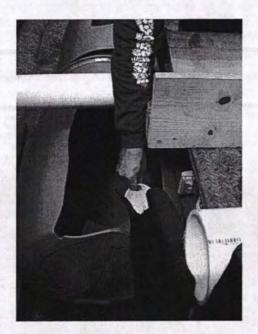
Test Set Up



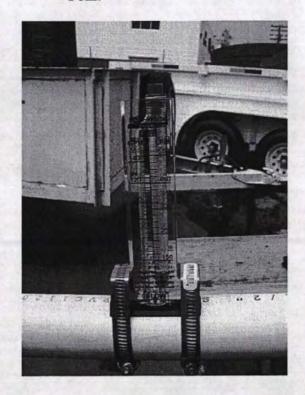








Collection Tank/Sampling Point



Before/After Comparison

Appendix B

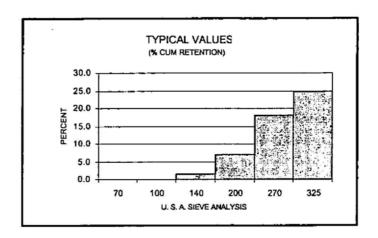


SIL-CO-SIL® 106

GROUND SILICA

PLANT: OTTAWA, ILLINOIS

PRODUCT DATA



			TYPICAL VALUES	
USA STD SIEVE SIZE		% RE	TAINED	% PASSING
MESH	MICRONS	INDIVIDUAL	CUMULATIVE	CUMULATIVE
70	212	0.0	0.0	100.0
100	150	0.1	0.1	99.9
140	106	1.4	1.5	98.5
200	75	5.5	7.0	93.0
270	53	11.0	18.0	82.0
325	45	7.0	25.0	75.0

TYPICAL PHYSICAL PROPERTIES

HARDNESS (Mohs) 7	
MELTING POINT (Degrees F) 3100	YELLOWNESS INDEX 4
MINERAL QUARTZ	SPECIFIC GRAVITY
pH 7	

TYPICAL CHEMICAL ANALYSIS, %

SiO ₂ (Silicon Dioxide)	MgO (Magnesium Oxide)<0.01 Na ₂ O (Sodium Oxide)<0.01
Al ₂ O ₃ (Aluminum Oxide) 0.05	K₂O (Potassium Oxide) 0.02
TiO ₂ (Titanium Dioxide) 0.02	LOI (Loss On Ignition) 0.1
CaO (Calcium Ovido) 0.01	

December 15, 1997

<u>DISCLAIMER</u>: The information set forth in this Product Data Sheet represents typical properties of the product described; the information and the typical values are not specifications. U.S. Silica Company makes no representation or warranty concerning the Products, expressed or implied, by this Product Data Sheet.

<u>WARNING</u>: The product contains crystalline silica - quartz, which can cause silicosis (an occupational lung disease) and lung cancer. For detailed information on the potential health effect of crystalline silica - quartz, see the U.S. Silica Company Material Safety Data Sheet.

D-TEK ANALYTICAL LABORATORIES, INC. 9020 Kenamar Drive, Suite 205 San Diego, CA 92121 (858) 566-4540 FAX (858) 566-4542

Bio Clean

2972 San Luis Rey Road Oceanside, CA 92054 Date Sampled: 06/10/07 Date Received: 06/11/07 Date Reported: 06/26/07

Attn: Michael Alberson

Project ID: Michael Alberson

Log Numbers: 07-3828 through 07-3833

Sample IDs: 610-1 Batch through 610-6 Run 5

The following are attached:

* Analytical Report

* Quality Control Report

* Chain-of-Custody

Testing was conducted using EPA or equivalent methods approved by the State of California Department of Health Services. All applicable QC met the required acceptance criteria.

Thank you for choosing D-TEK to serve your analytical needs!

Reviewed and approved:

Ellen Atienza

Operations Manager

Bio Clean

2972 San Luis Rey Road Oceanside, CA 92054

Attn: Michael Alberson

Date Reported: 06/26/07 Date Sampled: 06/10/07 Date Received: 06/11/07 Sample Type: WATER

Project ID: Michael Alberson

Influent

Log Number: 07-3828

Sample ID: 610-1 Batch

Concentrations

Analysis	Results	Units -	Method	Analyst/Date
Conductivity TKN Oil & Grease pH TSS Turbidity Cadmium Copper Lead Nickel Silver	1,080 10.4 13.0 8.65 100 36.0 0.302 0.354 0.492 0.52 < 0.01	umhos/cm mg/L mg/L mg/L mg/L mg/L mg/L mg/L mg/	EPA 120.1 SM4500NH3C EPA 1664 SM 4500-H+ B SM2540D EPA180.1 SM3113B SM3113B SM3113B SM3120B SM3120B	RR 06/11/07 OJ 06/14/07 RR 06/11/07 RR 06/11/07 RR 06/12/07 OJ 06/11/07 JV 06/15/07 JV 06/15/07 JV 06/15/07 JV 06/15/07 JV 06/15/07
Zinc Mercury	0.40 < 0.002	mg/L mg/L	SM3120B 3112B/245.1	JV 06/15/07 JV 06/19/07

Bio Clean 2972 San Luis Rey Road Oceanside, CA 92054

Run 4

Date Reported: 06/26/07 Date Sampled: 06/10/07 Date Received: 06/11/07 Sample Type: WATER

Attn: Michael Alberson

Project ID: Michael Alberson

Log Number: 07-3829 Sample ID: 610-2 Run 1

Analysis	Results	Units	Method	Analyst/Date
		·		
Conductivity	1,070	umhos/cm	EPA 120.1	RR 06/11/07
TKN	8.29	mg/L	SM4500NH3C	OJ 06/14/07
Oil & Grease	7.0	mg/L	EPA 1664	RR 06/11/07
pH .	8.65		SM 4500-H+ B	RR 06/11/07
TSS	3:	mg/L	SM2540D	RR 06/12/07
Turbidity	0.2	NTU	EPA180.1	OJ 06/11/07
Cadmium	0.192	mg/L	SM3113B	JV 06/15/07
Copper	0.115	mg/L	SM3113B	JV 06/15/07
Lead	0.008	mg/L	SM3113B	JV 06/12/07
Nickel	0.46	mg/L	SM3120B	JV 06/15/07
Silver	< 0.01	mg/L	SM3120B	JV 06/15/07
Zinc	0.06	mg/L	SM3120B	JV 06/15/07
Mercury	< 0.002	mg/L	3112B/245.1	JV 06/19/07

Bio Clean 2972 San Luis Rey Road Oceanside, CA 92054

Run 5

Date Reported: 06/26/07 Date Sampled: 06/10/07 Date Received: 06/11/07 Sample Type: WATER

Attn: Michael Alberson

Project ID: Michael Alberson

Log Number: 07-3830 Sample ID: 610-3 Run 2

Analysis	Results	Units	Method	Analyst/Date
	_	·		
Conductivity	1,070	umhos/cm	EPA 120.1	RR 06/11/07
TKN	8.64	mg/L·	SM4500NH3C	OJ 06/14/07
Oil & Grease	3.0	mg/L	EPA 1664	RR 06/11/07
рн	8.70	4,5	SM 4500-H+ B	RR 06/11/07
TSS	5	mg/L	SM2540D	RR 06/12/07
Turbidity	0.5	NTU	EPA180.1	OJ 06/11/07
Cadmium	0.193	mg/L	SM3113B	JV 06/15/07
Copper	0,119	mg/L	SM3113B	JV 06/15/07
Lead	0.007	mg/L	SM3113B	JV 06/12/07
Nickel	0.48	mg/L	SM3120B	JV 06/15/07
Silver	< 0.01	mg/L	SM3120B	JV 06/15/07
Zinc	0.06	mg/L	SM3120B	JV 06/15/07
Mercury	< 0.002	mg/L	3112B/245.1	JV 06/19/07

Bio Clean

2972 San Luis Rey Road Oceanside, CA 92054

Run 6

Date Reported: 06/26/07 Date Sampled: 06/10/07 Date Received: 06/11/07 Sample Type: WATER

Attn: Michael Alberson

Project ID: Michael Alberson

Log Number: 07-3831 Sample ID: 610-4 Run 3

Analysis	Results	Units	Method	Analyst/Date
		-		
Conductivity TKN Oil & Grease pH TSS Turbidity Cadmium Copper Lead Nickel	1,080 10.9 7.0 8.69 1 0.2 0.206 0.130 < 0.005 0.50	umhos/cm mg/L mg/L mg/L MTU mg/L mg/L mg/L mg/L mg/L	EPA 120.1 SM4500NH3C EPA 1664 SM 4500-H+ B SM2540D EPA180.1 SM3113B SM3113B SM3113B SM3113B SM3120B	RR 06/11/07 OJ 06/14/07 RR 06/11/07 RR 06/11/07 RR 06/12/07 OJ 06/11/07 JV 06/15/07 JV 06/15/07 JV 06/12/07 JV 06/15/07
Silver Zinc Mercury	< 0.01 0.05 < 0.002	mg/L mg/L	SM3120B SM3120B 3112B/245.1	JV 06/15/07 JV 06/15/07 JV 06/19/07

Date Reported: 06/26/07

Date Sampled: 06/10/07

Date Received: 06/11/07

WATER

Sample Type:

Bio Clean

2972 San Luis Rey Road Oceanside, CA 92054

Attn: Michael Alberson

Run 7

Project ID: Michael Alberson

Log Number: 07-3832 Sample ID: 610-5 Run 4

Analysis	Results	Units	Method	Analyst/Date
	-			
Conductivity	1,080	umhos/cm	EPA 120.1	RR 06/11/07
TKN	10.1	mg/L	SM4500NH3C	OJ 06/14/07
Oil & Grease	10.0	mg/L	EPA 1664	RR 06/11/07
PH	8.69		SM 4500-H+ B	RR 06/11/07
TSS	6	mg/L	SM2540D	RR 06/12/07
Turbidity	0.5	NTU	EPA180.1	OJ 06/11/07
Cadmium	0.203	mg/L	SM3113B	JV 06/15/07
Copper	0.110	mg/L	SM3113B	JV 06/15/07
Lead	< 0.005	mg/L	SM3113B	JV 06/12/07
Nickel	0.53	mg/L	SM3120B	JV 06/15/07
Silver	< 0.01	mg/L	SM3120B	JV 06/15/07
Zinc	0.05	mg/L	SM3120B	JV 06/15/07
Mercury	< 0.002	mg/L	3112B/245.1	JV 06/19/07

Bio Clean 2972 San Luis Rey Road Oceanside, CA 92054

Date Reported: 06/26/07 Date Sampled: 06/10/07 Date Received: 06/11/07

Attn: Michael Alberson

Run 8

Sample Type:

Project ID: Michael Alberson

Log Number: 07-3833 Sample ID: 610-6 Run 5

Analysis	Results	Units	Method	Analyst/Date
Conductivity	1,080	umhos/cm	EPA 120.1	RR 06/11/07
TKN	7.40	mg/L	SM4500NH3C	OJ 06/14/07
Oil & Grease	12.0	mg/L	EPA 1664	RR 06/11/07
pН	8.69		SM 4500-H+ B	RR 06/11/07
TSS	2	mg/L	SM2540D	RR 06/12/07
Tűrbidity	0.2	NTU	EPA180.1	OJ 06/11/07
Cadmium	0.193	mg/L	SM3113B	JV 06/15/07
Copper	0.117	mg/L	SM3113B	JV 06/15/07
Lead ·	< 0.005	mg/L	SM3113B	JV 06/12/07
Nickel	0.47	mg/L	SM3120B	JV 06/15/07
Silver	< 0.01	mg/L	SM3120B	JV 06/15/07
Zinc	0.05	mg/L	SM3120B	JV 06/15/07
Mercury	< 0.002	mg/L	3112B/245.1	JV 06/19/07

QUALITY CONTROL DATA REPORT

Report Date: 06/26/07

Log Numbers: 07-3828 through 07-3833

- * LCS Laboratory Control Sample. The LCS is a blank spiked with a known amount of method analyte(s) obtained from independent standards and is carried through all sample preparation and analytical procedures. Recoveries are calculated in order to evaluate method accuracy.
- * Spike The spike is an actual sample spiked with a known amount of method analyte(s) and is carried through all sample preparation and analytical procedures. Recoveries are calculated in order to evaluate potential matrix interferences.
- * RPD = Rel % Difference = ((Result 1 Result 2) / Average Result) X 100% The RPD provides a measure of method precision by comparing analytical results of 2 duplicate samples.
- * * Recovery = ((Spike Sample Result Sample Result) / Spike Conc) X 100% The result of the unspiked sample is treated as zero if it is less than established reporting limits.

QUALITY CONTROL DATA REPORT Method(s): Inorganics

Report Date: 06/26/07

Log Numbers: 07-3828 through 07-3833

No target analytes were detected in the Method Blanks.

Analysis	"Method	LCS % Recovery	Spike % Recovery	Duplicate RPD
				
Conductivity	EPA 120.1	100		
TKN	SM4500NH3C	100	83	1
Oil & Grease	EPA 1664	115		
Turbidity	EPA180.1	100		
_	EPAI80.1	100		
Cadmium	SM3113B	100	107	4
Copper	SM3113B	103	102	5
Lead	SM3113B	100	105	0
Nickel	SM3120B	99	108	5
Silver	SM3120B	94	103	9
Zinc	SM3120B	100	107	5
Mercury	3112B/245.1	100	102	2

D-TEK Analytical Laboratories, Inc.

9020 Kenamar Drive, Suite 205 San Diego, CA 92121 (858) 566-4540 FAX (858) 566-4542

BIO CLEAN 2972 San Luis Rey Road Oceanside, CA 92054

Attn: Michael Alberson

6/26/07 Date of Report: 6/10/07 Sampling Date: Date Sample Received: 6/11/07 6/17/07 Date Extracted: Date Analyzed: June 22, 2007 Analyzed By: EA Sample Type: Water **Project Name:** N/A

ANALYSES RESULTS

Log#	Sample ID:	Analysis: TPH Method: EPA 8015B Units: mg/l	
02 2020	CIO I Beeck	14	
07-3828	610-1 Batch	1.4	
07-3829	610-2 Run 1	ND	
07-3830	610-3 Run 2	ND	

 <sup>07-3830
 610-3</sup> Run 2
 ND

 07-3831
 610-4
 Run 3
 ND

 07-3832
 610-5
 Run 4
 ND

 07-3833
 610-6
 Run 5
 ND

TPH - Total Petroleum Hydrocarbons

DHS - Recommended Procedure From Leaking Underground Fuel Tank Field Manual, May 1989.

Total Petroleum Hydrocarbon analysis resulting in hydrocarbons of the range C4-C44. Sample quantitated against motor oil.

^{*} ND = none detected

D-TEK Analytical Laboratories, Inc.

9020 Kenamar Drive, Suite 205 San Diego, CA 92121 (858) 566-4540 FAX (858) 566-4542

QUALITY CONTROL DATA REPORT

Date:

6/26/07

Attn:

Michael Alberson

Date Analyzed: Analysis Method: June 22, 2007 EPA 8015 B

Sample Log #:

07-3828 to 07-3833

METHOD BLANK

No target analytes were detected in the method blank.

LABORATORY CONTROL SAMPLE

Compound	% Recovery	Dup % Recovery	%RPD
		*	
TPH-Motor oil	88		
TPH-Diesel	100	101	1
TPH-Gasoline	94	•	

QUALITY CONTROL TERMINOLOGY

LCS - LABORATORY CONTROL SAMPLE. Reported as % recovery of an independent standard carried through all sample
preparation procedures to verify method performance. Acceptable range is 80% - 120%. Any out-of-control QC data is clearly indicated.

Spike- environmental sample is matrix spiked with method compounds and % recovery of concentration spiked into sample is calculated. Reported as % recovery. Acceptable range for "Normal Matrix Sample" is 75% 125%. Any out-of-control QC data is clearly indicated.

Bio Clean

2972 San Luis Rey Road

Oceanside, CA 92054

Attn: Michael Alberson

Date Sampled: 06/10/07

Date Received: 06/11/07

Date Reported: 07/23/07

Project ID: Michael Alberson

Log Numbers: 07-4651 through 07-4656

Sample IDs: #610-1 Batch (07-3828) through #610-6 Run 5 (07-3833)

The following are attached:

* Analytical Report

* Quality Control Report

* Chain-of-Custody

TP O-P

Testing was conducted using EPA or equivalent methods approved by the State of California Department of Health Services. All applicable QC met the required acceptance criteria.

Thank you for choosing D-TEK to serve your analytical needs!

Reviewed and approved:

Ellen Atienza (

Operations Manager

Bio Clean

2972 San Luis Rey Road Oceanside, CA 92054

Influent

Concentration

Date Reported: 07/23/07 Date Sampled: 06/10/07 Date Received: 06/11/07 Sample Type: WATER

Attn: Michael Alberson

Project ID: Michael Alberson

Log Number: 07-4651

Sample ID: #610-1 Batch (07-3828)

Analysis	Results	Units	Method	Analyst/Date
o-Phosphate Total Phosphorus	3.98 1.37	mg/L mg/L	SM4500PE 4500PB5E	OJ 07/16/07 OJ 07/16/07

Date Reported: 07/23/07

Date Sampled: 06/10/07 Date Received: 06/11/07

Sample Type: WATER

Bio Clean

2972 San Luis Rey Road Oceanside, CA 92054

Attn: Michael Alberson

Run 4

Project ID: Michael Alberson

Log Number: 07-4652

Sample ID: #610-2 Run 1 (07-3829)

Analysis	Results	Units	Method	Analyst/Date
o-Phosphate Total Phosphorus	2.13 0.68	mg/L mg/L	SM4500PE 4500PB5E	OJ 07/16/07 OJ 07/16/07

Run 5

Bio Clean

2972 San Luis Rey Road

Oceanside, CA 92054

Attn: Michael Alberson

Date Reported: 07/23/07 Date Sampled: 06/10/07

Date Received: 06/11/07

Sample Type:

WATER

Project ID: Michael Alberson

Log Number: 07-4653

Sample ID: #610-3 Run 2 (07-3830)

Analysis	Results	Units	Method	Analyst/Date
o-Phosphate Total Phosphorus	2.15 0.75	mg/L mg/L	SM4500PE 4500PB5E	OJ 07/16/07 OJ 07/16/07

Bio Clean 2972 San Luis Rey Road Oceanside, CA 92054

Run 6

Date Reported: 07/23/07 Date Sampled: 06/10/07 Date Received: 06/11/07 Sample Type: WATER

Attn: Michael Alberson

Project ID: Michael Alberson

Log Number: 07-4654

Sample ID: #610-4 Run 3 (07-3831)

Analysis	Results	Units	Method	Analyst/Date
o-Phosphate Total Phosphorus	2.20 0.72	mg/L mg/L	SM4500PE 4500PB5E	OJ 07/16/07 OJ 07/16/07

Bio Clean 2972 San Luis Rey Road Oceanside, CA 92054

Run 7

Date Reported: 07/23/07 Date Sampled: 06/10/07 Date Received: 06/11/07 Sample Type: WATER

Attn: Michael Alberson

Project ID: Michael Alberson

Log Number: 07-4655

Sample ID: #610-5 Run 4 (07-3832)

Analysis	Results	Units	Method	Analyst/Date
o-Phosphate	2.11	mg/L	SM4500PE	OJ 07/16/07
Total Phosphorus		mg/L	4500PB5E	OJ 07/16/07

Bio Clean 2972 San Luis Rey Road Oceanside, CA 92054

Date Reported: 07/23/07 Date Sampled: 06/10/07 Date Received: 06/11/07

Sample Type: WATER

Attn: Michael Alberson

Run 8

Project ID: Michael Alberson

Log Number: 07-4656

Sample ID: #610-6 Run 5 (07-3833)

Analysis	Results	Units	Method	Analyst/Date
-				
o-Phosphate Total Phosphorus	2.04 0.70	mg/L mg/L	SM4500PE 4500PB5E	OJ 07/16/07 OJ 07/16/07

QUALITY CONTROL DATA REPORT

Report Date: 07/23/07

Log Numbers: 07-4651 through 07-4656

- * LCS Laboratory Control Sample. The LCS is a blank spiked with a known amount of method analyte(s) obtained from independent standards and is carried through all sample preparation and analytical procedures. Recoveries are calculated in order to evaluate method accuracy.
- * Spike The spike is an actual sample spiked with a known amount of method analyte(s) and is carried through all sample preparation and analytical procedures. Recoveries are calculated in order to evaluate potential matrix interferences.
- * RPD = Rel % Difference = ((Result 1 ~ Result 2) / Average Result) X 100% The RPD provides a measure of method precision by comparing analytical results of 2 duplicate samples.
- * * Recovery = ((Spike Sample Result Sample Result) / Spike Conc) X 100% The result of the unspiked sample is treated as zero if it is less than established reporting limits.

QUALITY CONTROL DATA REPORT Method(s): Inorganics

Report Date: 07/23/07

.

Log Numbers: 07-4651 through 07-4656

No target analytes were detected in the Method Blanks.

Analysis	Method	LCS % Recovery	Spike % Recovery	Duplicate RPD
	- 3		-	
o-Phosphate	SM4500PE	98	105	1
Total Phosphorus	4500PB5E	94	85	. 0

Bio Clean

Oceanside, CA 92029

Attn: Michael Alberson

Date Reported: 05/10/07

Date Sampled: 04/25/07 Date Received: 04/25/07

Sample Type: WATER

Project ID: N/A

Influent

Concentrations

Log Number: 07-2698

Sample ID: Std #1-001 Mixture

Anelysis	Results	Units	Method	Analyst/Date
Nitrate-N Oil & Grease pH Total Phosphorus TSS Cadmium Copper Lead Nickel Silver	5.43 360 7.07 5.12 73 0.584 0.951 0.201 0.642 0.04	mg/L mg/L mg/L mg/L mg/L mg/L	SM4500NO3E EPA 1664 SM 4500-H+ B 4500PBSE SM2540D SM3113B SM3113B SM3113B SM3113B SM3120B SM3120B	RR 04/25/07 RR 04/27/07 RR 04/25/07 OJ 04/30/07 RR 04/26/07 JV 05/04/07 JV 05/03/07 JV 05/02/07 JV 05/02/07
Zinc Mercury	0.009	mg/L	SM3120B 3112B/245.1	JV 05/02/07 JV 05/07/07

Bio Clean 2972 San Luis Rey Road Oceanside, CA 92054

Attn: Michael Alberson

Project ID: N/A

Date Reported: 05/10/07 Date Sampled: 04/25/07 Date Received: 04/25/07 Sample Type: WATER

1 - der one

Log Number: 07-2704

Sample ID: Special 007 Run Run 1

Analysis	Results	Units	Method	Analyst/Date
				
Nitrate-N	5.38	mg/L	SM4500NO3E	RR 04/25/07
Oil & Grease	11.0	mg/L	EPA 1664	RR 04/27/07
рн	7.21		SM 4500-H+ B	RR 04/25/07
Total Phosphorus	5.20	mg/L	4500PBSE	OJ 04/30/07
TSS	. 17	mg/L	SM2540D	RR 04/25/07
Cadmium	0.480	mg/L	SM3113B	JV 05/04/07
Copper	0.340	mg/L	SM3113B	JV 05/03/07
Lead	0.015	mg/L	SM3113B	JV 04/30/07
Nickel	0.599	mg/L	SM3120B	JV 05/02/07
Silver	< 0.01	mg/L	SM3120B	JV 05/01/07
Zinc	0.93	mg/L	SM3120B	JV 05/02/07
Mercury	< 0.002	mg/L	3112B/245.1	JV 05/07/07

INFLUENT Day 2

D-TER ANALYTICAL LABORATORIES, INC. 9020 Kenemar Drive, Suite 205 San Diego, CA 92121 (858) 566-4540 FAX (858) 566-4542

Bio Clean

2972 San Luis Rey Road Oceanside, CA 92054

Attn: Michael Alberson

Date Reported: 05/10/07 Date Sampled: 04/26/07 Date Received: 04/26/07

Sample Type: WATER

ACCU. MICHAGI AIDEIBOD

Influent Concentrations

Project ID: N/A

Log Number: 07-2735

Sample ID: Std #2-Batch 2 - Inflored

Analysis	Results	Units	Method	Analyst/Date
Conductivity	945	umhos/cm	EPA 120.1	RR 04/26/07
Nitrate-N Oil & Grease	4.87 67.0	mg/L	SM4500NO3E	RR 04/26/07
PH	7.13	mg/L	EPA 1664 SM 4500-H+ B	RR 04/27/07 RR 04/26/07
Total Phosphorus	3.81	mg/L	4500PB5E	OJ 04/30/07
TSS Cadmium	52	mg/L	SM2540D	RR 04/27/07
Copper	0.503 0.906	mg/L mg/L	SM3113B	JV 05/04/07
Lead ·	0.192	mg/L	SM3113B SM3113B	JV 05/03/07 JV 04/30/07
Nickel	0.582	mg/L	SM3120B	JV 05/02/07
Silver	0.04	mg/L	SM3120B	JV 05/01/07
Zinc	1.32	mg/L	SM3120B	JV 05/02/07
Mercury	0.006	.mg/L	3112B/245.1	JV 05/07/07

Date Reported: 05/10/07

Date Received: 04/26/07

04/26/07

WATER

Date Sampled:

Sample Type:

D-TEK ANALYTICAL LABORATORIES, INC. 9020 Kenamar Drive, Suite 205 San Diego, CA 92121 (858) 566-4540 FAX (858) 566-4542

Bio Clean 2972 San Luis Rey Road Oceanside, CA 92054

Attn: Michael Alberson

Project ID: N/A

Log Number: 07-2738

Sample ID: D010-Run Run 2

Analysis	Results:	Units	Method	Analyst/Date
		· · · · · · · · · · · · · · · · · · ·		
Conductivity	994	umhos/cm	EPA 120.1	RR 04/25/07
Nitrate-N	5.15	mg/L	SM4500NO3E	RR 04/26/07
Oil & Grease	1.0	mg/L	EPA 1664	RR 04/27/07
рH	9.49	M = ~ -	SM 4500-H+ B	RR 04/26/07
Total Phosphorus	0.46	mg/L	4500PB5E	OJ 04/30/07
TSS	15	mg/L	SM2540D	RR 04/27/07
Cadmium	0.010	mg/L	SM3113B	JV 05/04/07
Copper	0.009	mg/L	SM3113B	JV 05/03/07
Lead	< 0.005	mg/L	SM3113B	JV 04/30/07
Nickel	0.196	mg/L	SM3120B	JV 05/02/07
Silver	< 0.01	mg/L	SM3120B	JV 05/01/07
Zinc	< 0.05	mg/L	SM3120B	JV 05/02/07
Mercury	< 0.002	mg/L	3112B/245.1	JV 05/07/07

Date Reported: 05/10/07

Date Sampled: 04/26/07

Sample Type:

Date Received: 04/26/07

WATER

D-TEK ANALYTICAL LABORATORIES, INC. 9020 Kenemar Drive, Suite 205 San Diego, CA 92121 (858) 566-4540 FAX (858) 566-4542

Bio Clean 2972 San Luis Rey Road Oceanside, CA 92054

Attn: Michael Alberson

Project ID: N/A

Log Number: 07-2739

Sample ID: 011-Run : Run 3

Analysis	Results	Units	Method	Analyst/Date
			 	
Conductivity	996	umbos/cm	EPA 120.1	RR 04/26/07
Nitrate-N	5.43	mg/L.	- SM4500NO3E	RR 04/26/07
Oil & Grease	< 1.0	mg/L	EPA 1664	RR 04/27/07
рH	9.53		SM 4500-H+ B	RR 04/26/07
Notal Phosphorus	0.39	mg/L	4500PB5E	OJ 04/30/07
TSS	1,3	mg/L	SM2540D	RR 04/27/07
Cadmium	0.006	mg/L	SM3113B	JV 05/04/07
Copper	0.005	mg/L	SM31.13B	JV 05/03/07
Lead	< 0.005	mg/L	SM3113B	JV 04/30/07
Nickel	0.180	mg/L	SM3120B	JV 05/02/07
Silver	< 0.01	mg/L	SM3120B	JV 05/01/07
Zinc	< 0.05	mg/L	SM3120B	JV 05/02/07
Mercury	< 0.002	mg/L	3112B/245.1	JV 05/07/07

QUALITY CONTROL DATA REPORT Method(s): Inorganics

Report Date: 05/10/07

Log Numbers: 07-2735 through 07-2740

No target enalytes were detected in the Method Blanks.

Analysis	" Method	LCS % Recovery	Spike % Recovery	Duplicate RPD
			 .	
Conductivity	EPA 120.1	99		
Nitrate-N	SM4500NO3E	99	105	2
Oil & Grease	EPA 1664	92		
Total Phosphorus	4500PB5E	88	91	0
Cadmium	SM3113B	100	99	. 1
Copper	SM3113B	98	102	4
Lead	SM3113B	92	90	5
Nickel	SM3120B	1.00	99	2
Silver	SM3120B	94	93	3
Zinc	SM3120B	104	96	1
Mercury	3112B/245.1	106	96	2

Project: De Portola Rd. Rehab Project

Prepared for:
Aldo Licitra
City of Temecula
43200 BUSINESS PARK DR
Temecula, CA 92589

Objective:

Acceptance of Bio Clean High Capacity GISB Media Filter –
For Curb Type Catch Basins
As an "Approved Equal"



ENVIRONMENTAL STOROSALCES, INC.

Information Package on:

Bio Clean High Capacity GISB Media Filter with BioMediaGREEN

Prepared by:
Zach Kent
Bio Clean Environmental Services, Inc.
Oceanside, CA
760-433-7640

Summary of Results

The following information found in this document provide the support and facts needed to prove that the Bio Clean High Capacity GISB Media Filter utilizing the filter media BioMediaGREEN meets and in most cases exceeds that of "The ClearWater BMP" manufactured by ClearWater Solutions, Inc. for use within standard catch basin structures.

Comparison of Materials

Description of Item	Bio Clean GISB Media Filter w/BMG	The ClearWater BMP
Trash Basket Fabrication	Fiberglass & Stainless Steel	Plastic Netting
Filter Insert Storage Capacity	5.08 cubic feet	4.5 cubic feet
Filter Insert System Fabrication	Fiberglass & Stainless Steel	Stainless Steel & Plastic Netting
Trash and Debris Storage	5 cubic feet	4.5 cubic feet
Treatment Stages	Multiple	Multiple
Drainage	Less than 24 hours	Less than 24 hours
Installation	Easily Retrofited Easily Retrof	

Comparison of Performance

BioClean GISB Media Filter w/ BioMediaGREEN (BMG)

Constituent	Removal Efficiency
TSS (very fine – 20 micron mean)	85.35%
Oils & Grease	90.7%
Dissolved Copper Only	79.15%
Dissolved Lead Only	98.19%
Dissolved Zinc Only	78.22%
Fecal Coliform	68%

The ClearWater BMP

Constituent	Removal Efficiency
TSS (wide size range) *mostly large particles	97%
Oils & Grease	86%
Total Copper (**includes particulates)	28%
Total Lead (**includes particulates)	81%
Total Zinc (**includes particulates)	83%
Fecal Coliform	Not Tested

^{*} The TSS particle size distribution is made up of mainly larger particles which are very easy to remove from passing stormwater. Greater than 90% of the particles are greater than 100 microns in size. In comparison the TSS particle size distribution used to test the BioMediaGREEN has a mean particle size of 19 microns and 90% of the particles are less than 100 microns. Based upon the huge variation in the PDS tested, the removal of fine TSS and large TSS is much greater for the BioMediaGREEN filtration media.

^{**} Total metals include both particulates which are easier to move and dissolved which are more difficult to remove. The BioMediaGREEN looked at only removal of the more difficult dissolved portion. Considering the 79.15% removal efficiency for dissolved copper compared with the BioMediaGREEN compared to the 28% of total copper with the ClearWater BMP it can be stated that ability of the BioMediaGREEN to remove metals is much greater than that of the ClearWater BMP.

Conclusion

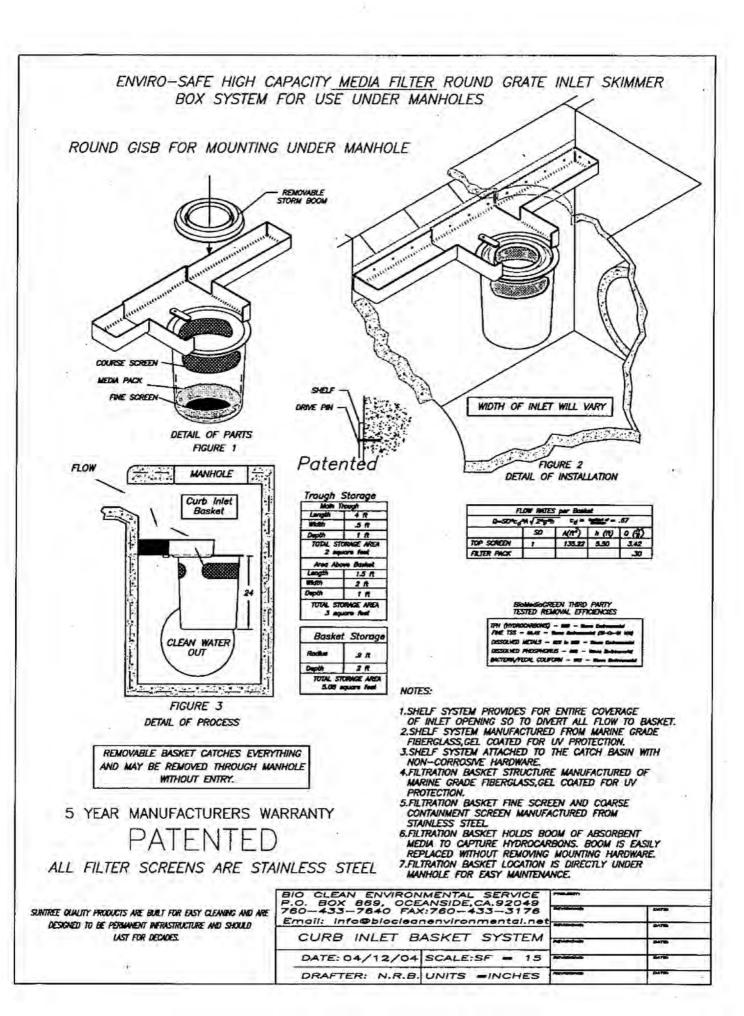
Based upon the information provided in the comparison of materials, hydraulics, similarity in design/application, and removal efficiency the Bio Clean GISB Media Filter with BioMediaGREEN meets and in many cases exceeds the standards, capacities, and performance of the ClearWater BMP and therefore can be accepted as an or equal for use on this project.

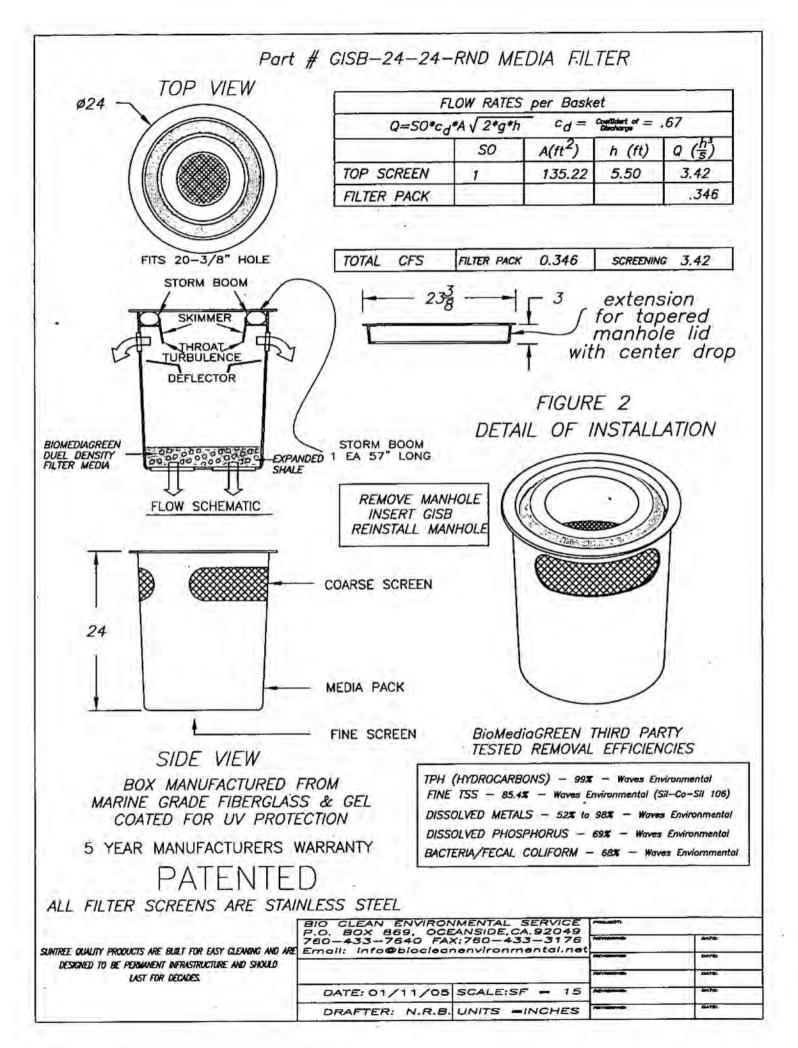
In addition to the above items of comparison the Bio Clean GISB Media Filter with BioMediaGREEN is also proven to remove 69% of dissolved phosphorus.

Following is supporting information, drawings, and performance data for the Bio Clean GISB Media Filter with BioMediaGREEN. If more information is needed for this "OR EQUAL" approval please feel free to contact me directly.

Respectfully,

Zach Kent





BIO MEDIA-GREEN

Pollutant Removal Performance Summary

Test Run	p	н	TSS	(mg/L)	TKN	(mg/L)	Phosp	olved shorus (AL)	Ort Phosp	horus	Disso		Disse	
	Influent	Effluent	mfluent	Effluent	Influent	Effluent	Influent	Effluent	Influent	Effluent	Influent	Effluent	Influent	Effluent
1	7.07	7.21	73	17							0.584	0.48	0.951	0.34
2	7.13	9.49	52	15			3.81	0.46			0.503	0.01	0.906	0.009
3	7.13	9.53	52	13			3.81	0.39			0.503	0.006	0.906	0.005
4	8.65	8.65	100	3	10.4	8.29	1.37	0.68	3.98	3.13	0.302	0.192	0.354	0.115
5	6.05	8.7	100	5	10.4	8.64	1.37	0.75	3.98	2.15	0.302	0.193	0.354	D.119
6	8.65	8.69	100	1	10.4	10.9	1.37	0.72	3.98	2.2	0.302	0.206	0.354	0.13
7	8.65	8.69	100	6	10.4	10.1	1.37	0.69	3.98	2.11	0.302	0.203	0.354	0.11
8	6.65	8.59	100	2	10,4	7.4	1.37	0.7	3.98	2.04	0.302	0.193	0.354	0.117
Averages	8.0725	8.70625	84.63	12.40	10.40	9.07	2.07	0.63	3.98	2.33	0.39	0.19	0.57	0.12
Average Removal Efficiency (%)			85.3	35%	12.0	13%	69.6	66%	41.5	16%	52.1	ex .	79.1	15%

Mean particle size = 19

Test Run		ed Lead	100	red Zinc	Diss. Mercu	0.00	Oil & (me		ТРН	(mg/L)	Turbid	ity (NTU)
	Influent	Effent	Influent	Effluent	Influent	Effluent	Influent	Effluent	Influent	Effluent	Influent	Effluent
4	0.201	0.015	1.33	0.93	0.009	0.002	360	11	l			- 1
2	0.192	0.005	1.32	0.05	0.005	0.002	67	1				- 1
3	0.192	0.005	1.32	0.05	0.006	0.002	67	. 1	Į			- 1
	0.492	0.008	0.4	0.06	n/d	nAd	13	7	1.4	0	36	0.2
5	0.492	0.007	0.4	0.06	nAd	n/d	13	3	1.4	0	38	0.5
Б	0.492	0.005	0.4	0.05	nAd	n/d	13	7	1.4	D	38	0.2
7	0.492	0.005	0.4	0.05	nAd	n/d	13	10	1.4	0	36	0,5
В	0.492	0.005	0.4	0.05	rv/d	n/d	13	12	1.4	0	36	0.2
Averages	0.38	0.01	0.75	0.16	0.01	0.00	69.88	6.50	1.40	0.00	38.00	0.32
Average Removal Efficiency (%)	111.1	19%	783	22%	71.4	13%	90.7	70%	100.	00%	99.	11%

Test Run		oliform	Fecal Cotiform		
	trafluent	Effluent	Influent	Effluent	
1	1600000	1600000	1250000	500000	
2	1600000	500000	1250000	300000	
3	1600000	500000	1250000	300000	
*	1600000	900000	1250000	500000	
Averages	1600000	875000	1250000	400000	
Average Removal Efficiency (%)	45.31%		64.1	90%	

"Laboratory Testing - Average Ramoval Efficiencies. Tested at Flow Rate of 3 GPM Per Square Foot Media Surface Avea & Minimum Head.

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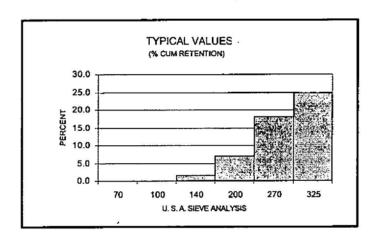


SIL-CO-SIL® 106

GROUND SILICA

PLANT: OTTAWA, ILLINOIS

PRODUCT DATA



ı				TYPICAL VALUES	
	USA STD S	SIEVE SIZE	% RET	AINED	% PASSING
ı	MESH	MICRONS	INDIVIDUAL	CUMULATIVE	CUMULATIVE
	70	212	0.0	0.0	100.0
	100	150	0.1	0.1	99.9
	140	106	1.4	1.5	98.5
	200	75	5.5	7.0	93.0
	270	53	11.0	18.0	82.0
	325	45	7.0	25.0	75.0

TYPICAL PHYSICAL PROPERTIES

HARDNESS (Mohs)	REFLECTANCE (%)	. 4
pH 7		

TYPICAL CHEMICAL ANALYSIS, %

SiO₂ (Silicon Dioxide)	MgO (Magnesium Oxide)<0.01 Na₂O (Sodium Oxide)<0.01
Al ₂ O ₃ (Aluminum Oxide) 0.05	K ₂ O (Potassium Oxide) 0.02
TiO ₂ (Titanium Dioxide) 0.02	LOI (Loss On Ignition) 0.1
CaO (Calcium Oxide) 0.01	

December 15, 1997

DISCLAIMER: The information set forth in this Product Data Sheet represents typical properties of the product described; the information and the typical values are not specifications. U.S. Silica Company makes no representation or warranty concerning the Products, expressed or implied, by this Product Data Sheet.

<u>WARNING</u>: The product contains crystalline silica - quartz, which can cause silicosis (an occupational lung disease) and lung cancer. For detailed information on the potential health effect of crystalline silica - quartz, see the U.S. Silica Company Material Safety Data Sheet.

Hydraulic-Conductivity Flow Calculator

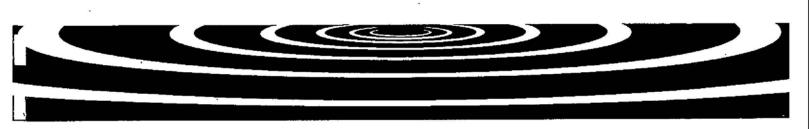
Calculates vertically downward flow rates given hydraulic conductivity, media thickness, and water head.

Enter the Hydraulic Conductivity (k) of the Value accepted.	.1190	ft/day			
2. Select the Units for the Hydraulic Conduct (Enter "M" for Metric or "E" for Engl		Selection accept	English ed.		
Hydraulic-Conductivity Conversions	Meters per Day:	363	m/day		
	Meters per Hour:	15.1	m/hr		
	Meters per Minute:	0.252	m/min		
	Meters per Second:	0.0042	m/s		
	Feet per Day:	1,190	ft/day		
	Feet per Hour:	49.6	ft/hr		
	Feet per Minute:	0.826	ft/min		
	Feet per Second:	0.0138	ft/s		
Enter the Thickness of the Filter Media in Value accepted.	3	inches			
4. Enter the Water Depth above the Media Solue accepted.	21 ,7	inches			
5. Enter the Horizontal Surface Area in squa	3.14	sqft			
Calculated Flow Rates	Gallons per Minute:	155	gpm		
	Cubic Feet per Second:	0.346	cfs		
Optional Reynolds Number Check (Verifies Darcian Flow)					
Enter the D30 representative grain diameter Value accepted.	20	um			
Calculated Reynolds Number (Should be less the	0.045				

Notes:

- 1. Values of hydraulic conductivity greater than 10,000 meters per day (and the equivalent in feet per day) will provide a warning that flow may be exceeding Darcian flow. This warning has no effect on calculator operation. Accordingly, check the Reynolds Number using the provided option.
- 2. Values of filter media thickness and water depth above media greater than 100 inches will provide a warning. As with several other warnings, this warning was provided to identify a possible incorrect value entry and does not affect the calculator operation.
- 3. Values of horizontal surface area that are greater than 10,000 square feet will provide a warning. Again, as with the other warnings, the warning was provided to identify possible incorrect value entries and does not affect calculator operation.
- 4. The D30 representative grain diameter (often stated d₃₀) is the grain diameter that allows 30 percent passing as determined by performing a sieve analysis.

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Modular Wetland Systems, Inc. BioMediaGREEN - Bacteria Removal Testing

Prepared for

Modular Wetland Systems, Inc.

December 2007

Prepared By

Waves Environmental

P.O. Box 462290 Escondido, CA 92046-2290 Phone: 760-743-6720

www.wavesenv.com

Testing Laboratory

Weston Solutions

2433 Impala Drive Carlsbad, CA 92008 Phone: 760-931-8081

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SECTION	PAGE
Scope of Work	3
Description of Testing Apparatus	3
Test Set Up	3
Testing Procedure	4
Results	5
Summary	6
Appendix A	7
Appendix B	9.

Reference: Bacteria Removal Testing

BioMediaGREEN Stormwater Filtration Media.

Waves Environmental is pleased to submit this report to Modular Wetland Systems, Inc. This report includes the laboratory analysis and photo documentation of testing procedures. The conclusions and recommendations are not included in this report since they are not part of the scope of work with Waves Environmental.

Scope of Work

Waves Environmental measured the percentage removal of various bacteria indicators retained/captured by BioMediaGREEN stormwater filtration media. The laboratory testing was accomplished by a specially designed flume to control flow and head through the filtration media. The dimension of the media tested was 2.0 feet, wide by 0.5 feet high and 0.25 feet thick. The treatment surface area is approximately 1.00 square feet. The contaminated stormwater used for this test was extracted from a local stormwater outfall that is notorious for having high levels of total and fecal Coliform. The contaminated stormwater was quickly collected in two sterile 55 gallon plastic barrels and delivered to the test facility within 30 minutes from the start of the extraction. The contaminated stormwater was run through the media over a series of four 8 minute runs. Numerous grab samples were taken from the influent and effluent ends of the test unit. Grab samples were taken to the lab for analysis. A summary of the resulting data is presented in the report.

Description of Testing Apparatus

The test flume was placed on an adjustable platform to allow for an appropriate amount of head, simulating conditions found in the field. A 2.0 foot wide slab of BioMediaGREEN was placed inside the flume. A 55 gallon barrel modified with a valve controlled discharge port at the bottom was used to release the contaminated water through a 2" valve into the flume at a rate of 10 gpm. Flow through the media was anticipated to be between 2 and 5 gpm once a maximum head of 0.5 feet was reached.

Test Set Up

The test was designed to simulate the pollution that occurs during a rainfall event to measure the effectiveness of BioMediaGREEN. Since the contaminated water was pulled from a local stormwater discharge pipe the concentrations are representative of actual field conditions. Michael Alberson a CPESC, CPSWQ and REA from Waves Environmental performed the testing, measurements, and pollutant sampling. A specially designed flume was constructed and lined with rubber to provide a clean and uncontaminated surface to perform the testing.

The contaminated water was collected from a 60" RCP stormwater discharge pipe following a small storm event in the coastal area of northern San Diego County. 110 gallons of stormwater was collected from the location at approximately 12:40 PM on the 29th of November, 2007. The stormwater was delivered at 1:10 PM to commence testing. Prior to testing the collected runoff was thoroughly mixed to provide uniform concentrations throughout the water column. Once mixed thoroughly a grab sample was taken form the tank influent (Weston ID 112907 1). This sample was taken at 1:18 PM another influent sample was taken at 2:11 (Weston ID 112907 4) to provide an average. This will allow for an average to be taken and to account for possible concentration fluctuations among samples. These samples provided the influent levels of the polluted water to be compared with 4 samples of effluent levels after treatment through the filtration media.

Testing Procedure

A flow meter and control valve regulated the flow between 2 to 5 gpm. Each test was conducted for approximately 8 minutes. Three grabs for each sample of effluent water were used to get an average sample concentration. The sampling procedure of the effluent water is as follows: The contaminated water was allowed to flow through the filter for two minutes then one third of the effluent (treated) water was collected and poured into the sampling bottle. The second and third samples of treated water were taken at three minutes and four minutes, respectively, and added to the sampling bottle.

Since the stormwater was collected in the field it was observed that the visible hydrocarbons (a rainbow sheen floating on the surface) and TSS was present in the influent (before the BioMediaGREEN) and were not visible after leaving the backside (effluent), which indicated that the hydrocarbons were being absorbed by the media and TSS was being retained within the filter media. The water collected in the downstream of the filter media was surprisingly clear and turbidity was observed to be very low.

As part of the initial sample of the influent readings where taken for temperature and wind. This initial information is as follows: time of testing started at 1:18 PM, wind was between 0.0-0.9 mph, temperature 74.1 degrees F.

Results

BioMediaGREEN

Run	Pollutant	Influent (MPN/100 mL)	Effluent (MPN/100 mL)	Percent Reduction
1-	Total Coliform	1600000	1600000	0%
	Fecal Coliform	1250000	500000	60%
2-	Total Coliform	1600000	500000	69%
	Fecal Coliform	1250000	300000	76%
3-	Total Coliform	1600000	500000	69%
	Fecal Coliform	1250000	300000	76%
4-	Total Coliform	1600000	900000	44%
	Fecal Coliform	1250000	500000	60%

Summary of Results

Summary

Pollutant	Influent (MPN/100 mL)	Effluent (MPN/100 mL)	Percent Reduction
Total Coliform	1600000	875000	,45.31%
 Fecal Coliform	1250000	400000	68%

Summary

A total of four runs were performed to provide verifiable removal efficiencies. After four 8 minute runs through the BioMediaGREEN stormwater filtration media the effluent concentrations coming out of the system where analyzed and compared to influent concentrations. An influent concentration was sampled at the influent end of the system, prior to entering the systems filter processes. The BioMediaGREEN demonstrated some substantial reductions in the concentrations of fecal Coliform and total Coliform. Following is a summary of the effluent concentrations and resulting removal efficiencies.

A concentration limit of 1600000 MPN/100mL was set for total and fecal Coliform. This limit was hit during lab analysis. All influent concentrations for total Coliform were at or over the limit. Thus actual concentrations may have been higher.

Average influent concentrations for total Coliform were 1600000 MPN/100 mL. Average effluent concentrations of total Coliform were 875000 MPN/100 mL, resulting in an average reduction of 45.31%.

Average influent concentrations for fecal Coliform were 1250000 MPN/100 mL. Average effluent concentrations of fecal Coliform were 400000 MPN/100 mL, resulting in an average reduction of 68%.

Appendix A

Testing Photos



Runoff Extraction Location



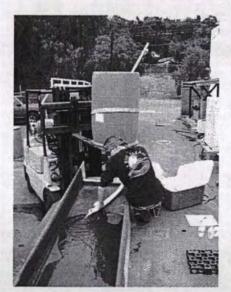
Pump



Extraction Set Up



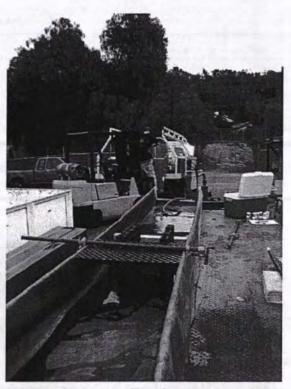
Unloading of Runoff Samples



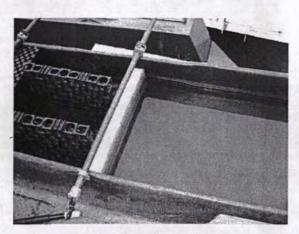
Release of Runoff into Test Flume



Effluent End of Test Flume



Test Setup



Run 1 – Runoff Flowing Through BioMediaGREEN

Appendix B

Weston Solutions, Inc.

Analytical Report

Client:

Bio Clean

Project: Bio Media Green 1

Client Sample ID:

See Below

Weston Sample ID: See Below Date Received: November 29, 2007

Date Test Started: November 29, 2007

Date Tests Ended: December 3, 2007

Matrix:

Water

Bacterial Analysis Using Multiple Tube Fermentation/MPN, IDEXX Colilert

Methods: SM 9221B, E and SM 9223, & SM 9223B

Microorganisms Tested: Total/Fecal Coliforms

Bacterial Summary

Coliform analyses based on dilutions providing results between 20 - 1,600,000 MPN/100mL

		* 2 * 3		Total Coliforms	Fecal Coliforms
Sample	e de	Date Sample			MPN/100
建划D 。	-Weston ID	Taken	Taken	mL .	mL
°0 11 €	1,12907.1	11/29/2007	1318	- 1,600,000	, 1,600,000
2012	112907.2	11/29/2007	1322	1,600,000	500,000
3.3	112907.3	11/29/2007	1335	500,000	300,000
16、48。河	112907.4	11/29/2007	1411	. 1,600,000	900,000
部第5時間	112907.5	11/29/2007	1413	500,000	300,000
6.5	112907.6	11/29/2007	1425	900,000	500,000

Microbiology Lab Supervisor (Anthony Trinh)

12/12/2007 Date

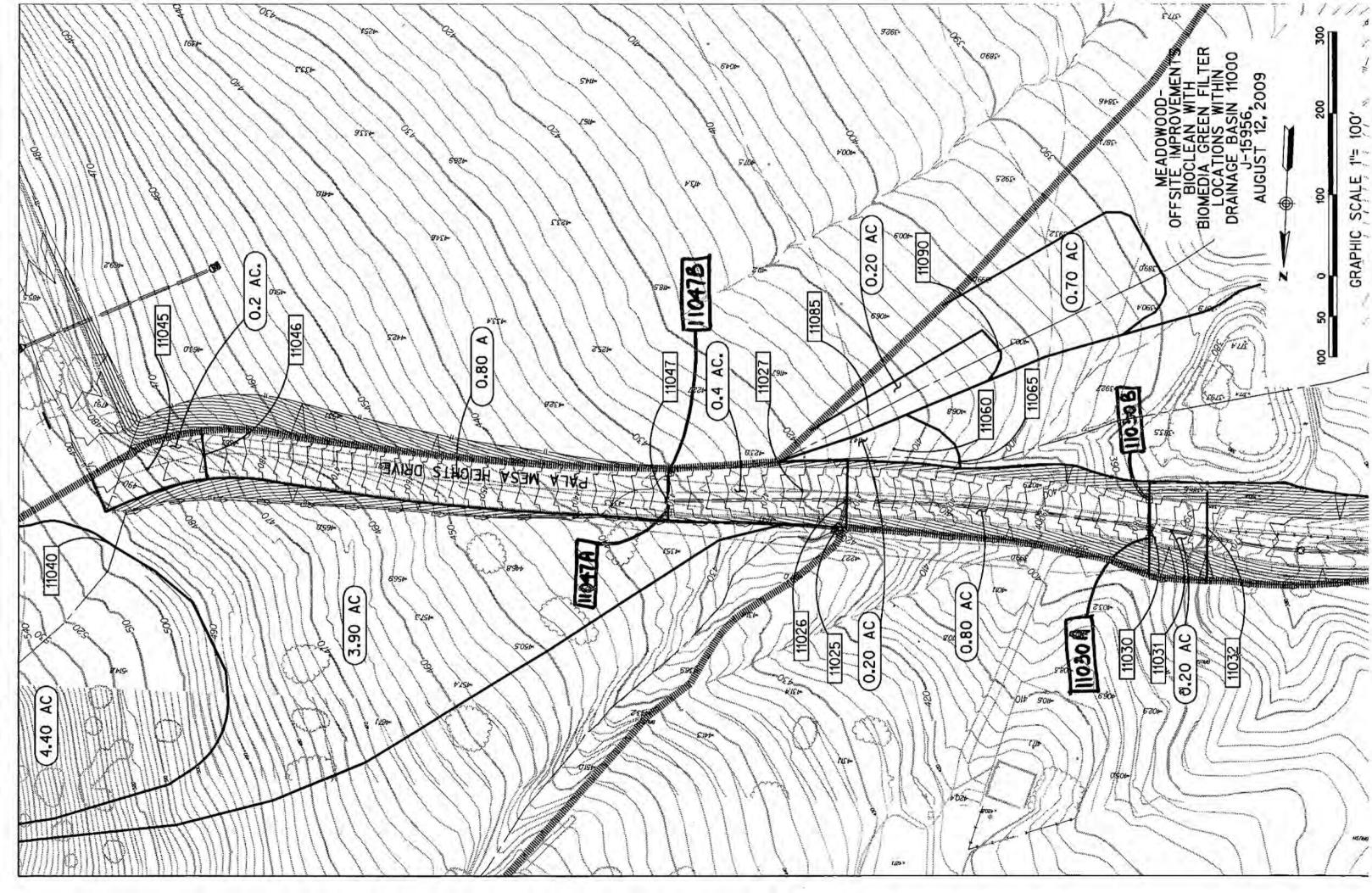
BioClean Inlet Filter Insert with a BioMEDIA Green Filter (Offsite)

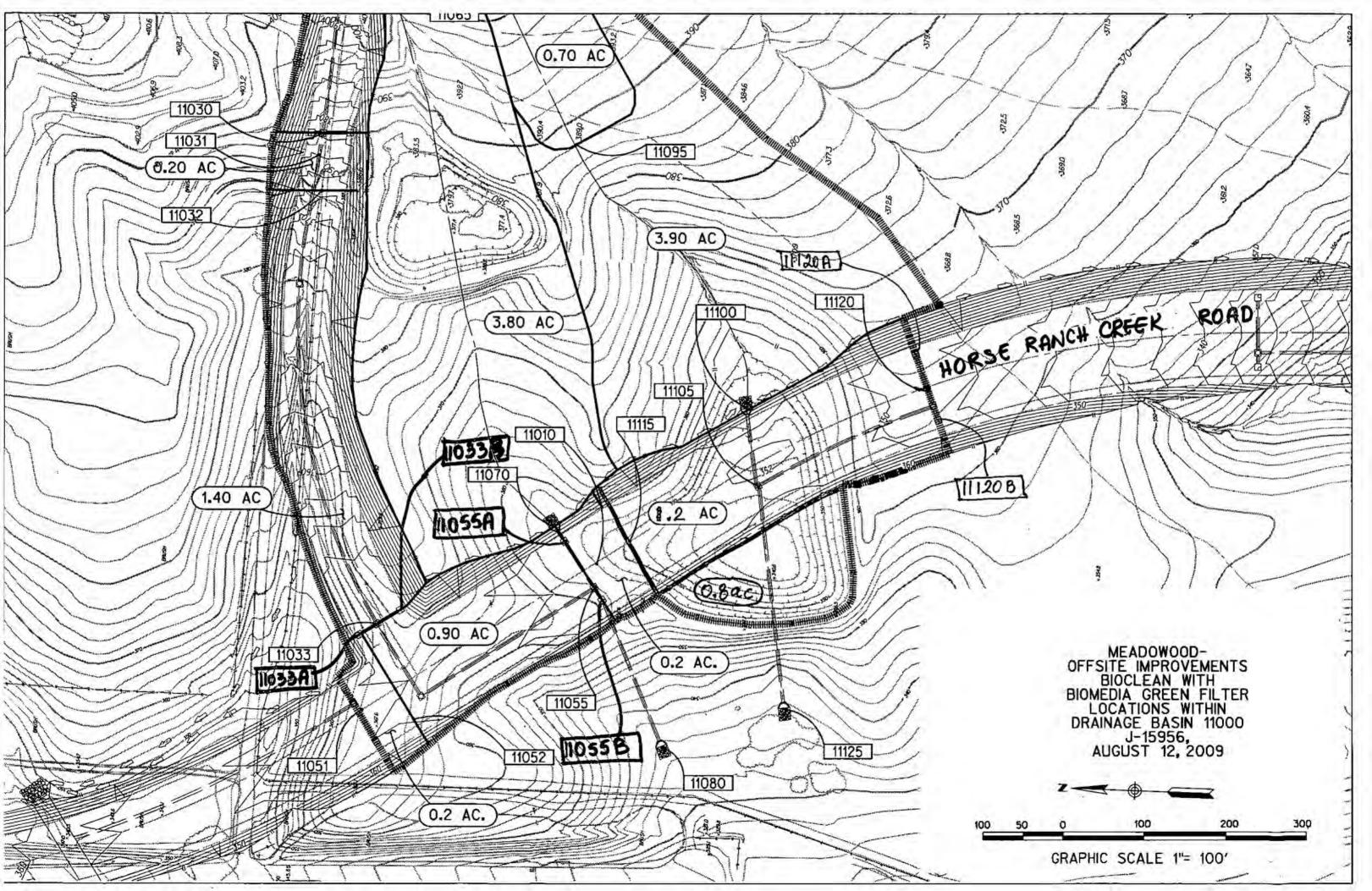
WATER QUALITY CALCULATIONS FOR OFFSITE IMPROVEMENTS

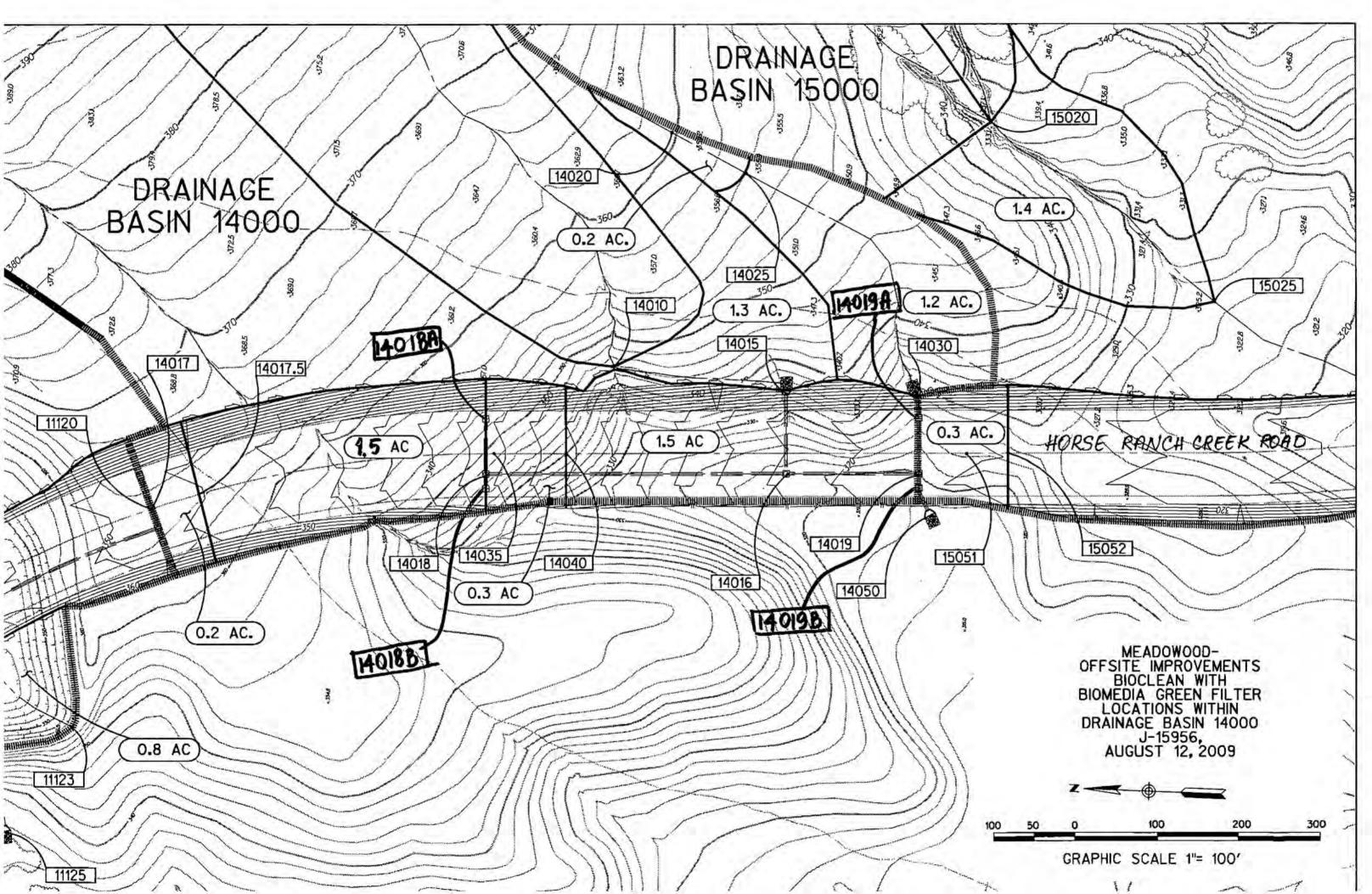
Bioclean Filter Inserts with BioMEDIA Green Filter (Horse Ranch Creek Road, Pala Mesa Heights Drive, Pala Mesa Drive/existing Pankey Road and Street "R")

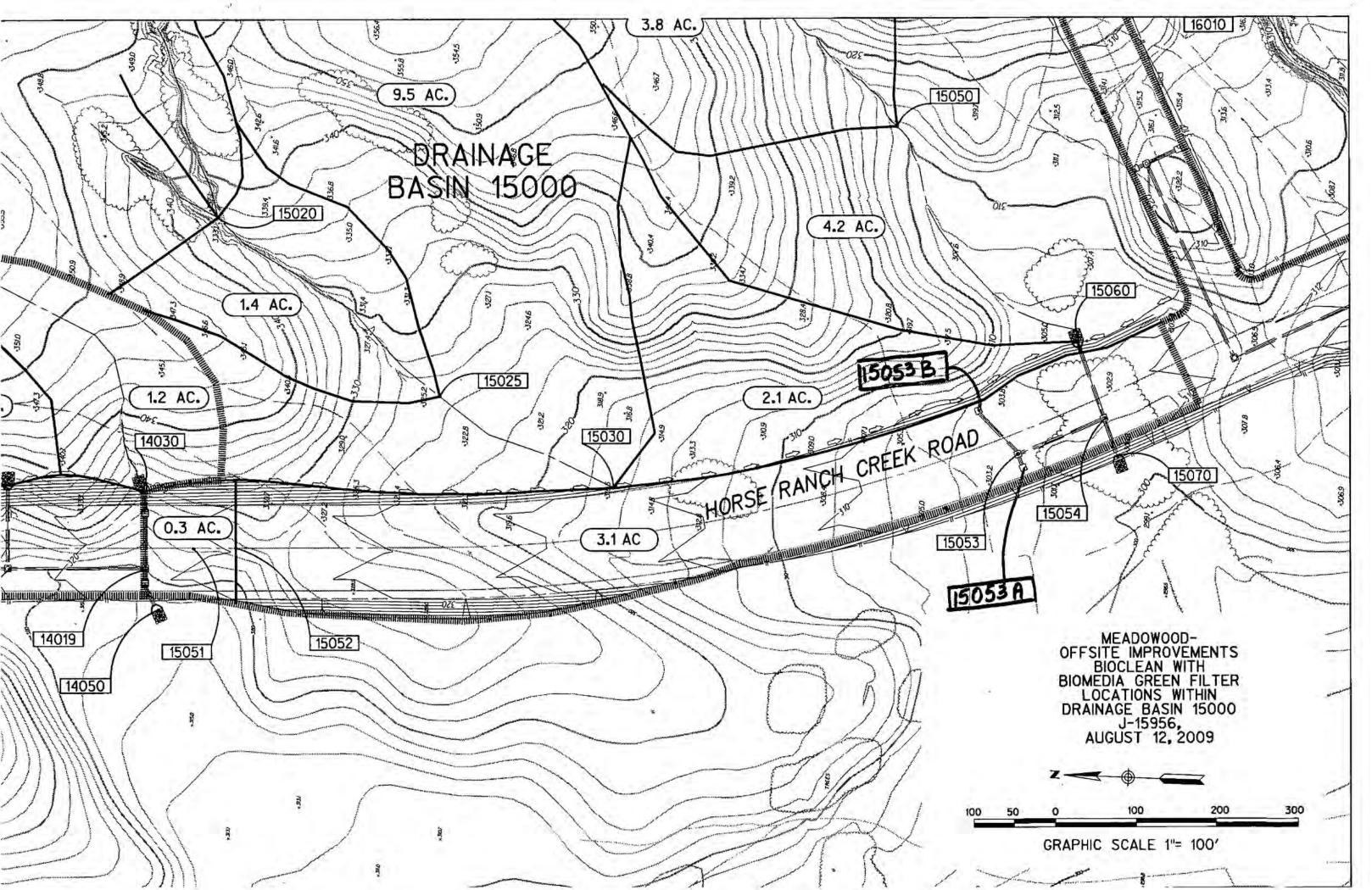
Inlet	Tributary Area	Runoff Coefficient	Intensity	Treatment Q	Bioclean Capacity	Is Capacity Acceptable?
	(Acres) ²		(in/hr)	(cfs)	(cfs)	
11000(11047A)	0.50	0.9	0.2	0.09	0.47	YES
11000(11047B)	0.50	0.9	0.2	0.09	0.47	YES
11000(11030A)	0.60	0.9	0.2	0.11	0.47	YES
11000(11030B)	0.60	0.9	0.2	0.11	0.47	YES
11000(11033A)	0.70	0.9	0.2	0.13	0.47	YES
11000(11033B)	0.90	0.9	0.2	0.16	0.47	YES
11000(11055A)	0.50	0.9	0.2	0.09	0.47	YES
11000(11055B)	0.60	0.9	0.2	0.11	0.47	YES
11000(11120A)	0.70	0.9	0.2	0.13	0.47	YES
11000(11120B)	0.70	0.9	0.2	0.13	0.47	YES
14000(14018A)	0.90	0.9	0.2	0.16	0.47	YES
14000(14018B)	0.80	0.9	0.2	0.14	0.47	YES
14000(14019A)	1.00	0.9	0.2	0.18	0.47	YES
14000(14019B)	0.80	0.9	0.2	0.14	0.47	YES
15000(15053A)	1.90	0.9	0.2	0.34	0.47	YES
15000(15053B)	1.50	0.9	0.2	0.27	0.47	YES
18000(18010A)	0.60	0.9	0.2	0.11	0.47	YES
18000(18010B)	0.70	0.9	0.2	0.13	0.47	YES
19000(19010A)	0.70	0.9	0.2	0.13	0.47	YES
19000(19010B)	0.60	0.9	0.2	0.11	0.47	YES
20000(20010A)	0.75	0.9	0.2	0.14	0.47	YES
20000(20010B)	0.65	0.9	0.2	0.12	0.47	YES
20000(20030A)	0.45	0.9	0.2	0.08	0.47	YES
20000(20030B)	0.45	0.9	0.2	0.08	0.47	YES
20000(20045A)	0.35	0.9	0.2	0.06	0.47	YES
20000(20045B)	0.35	0.9	0.2	0.06	0.47	YES

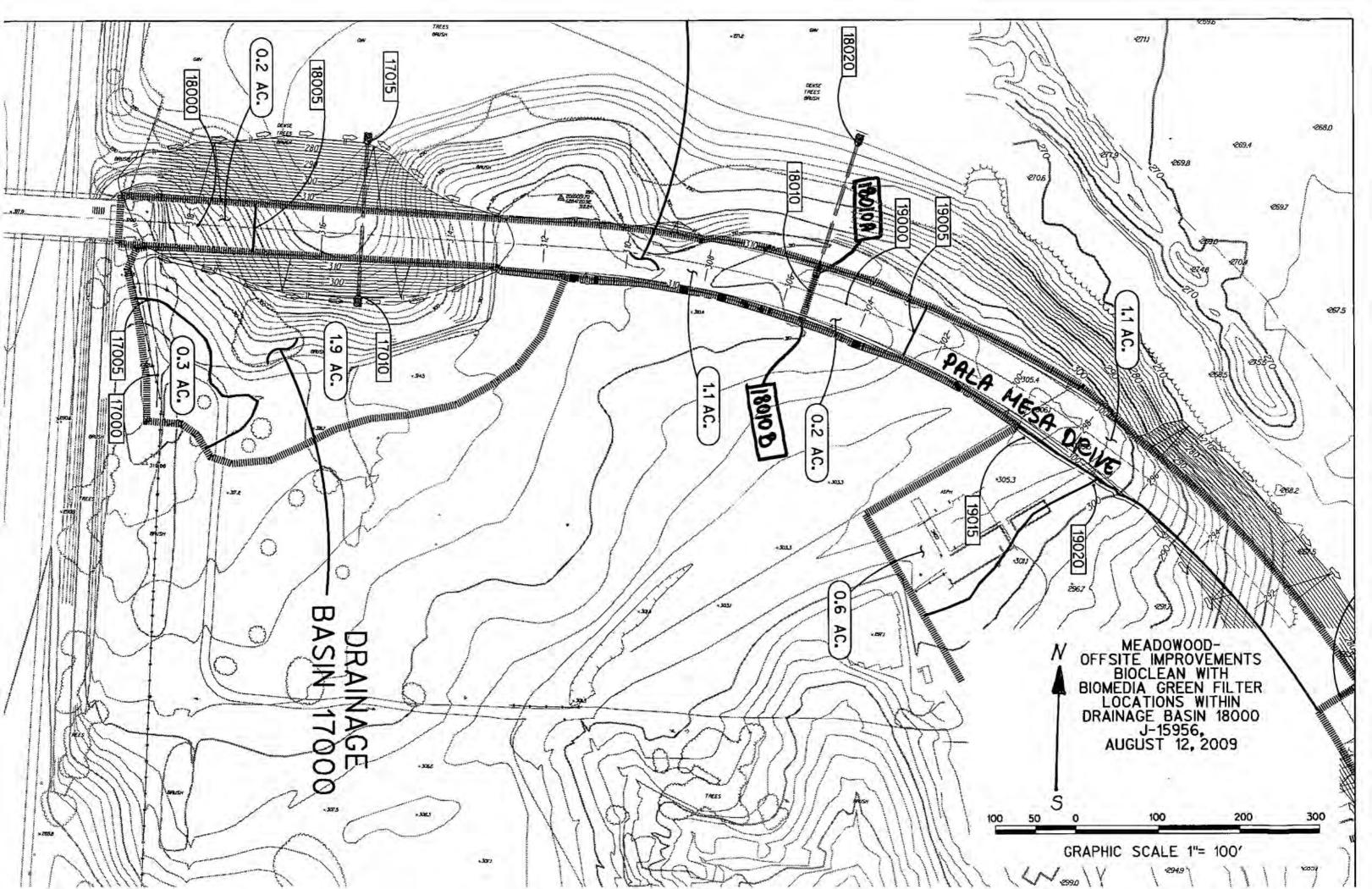
²⁾ See Exhibit titled Water Quality Exhibit for Meadowood Vesting Tentative Map Offsite Improvements, BioMEDIA Green Filter sizing

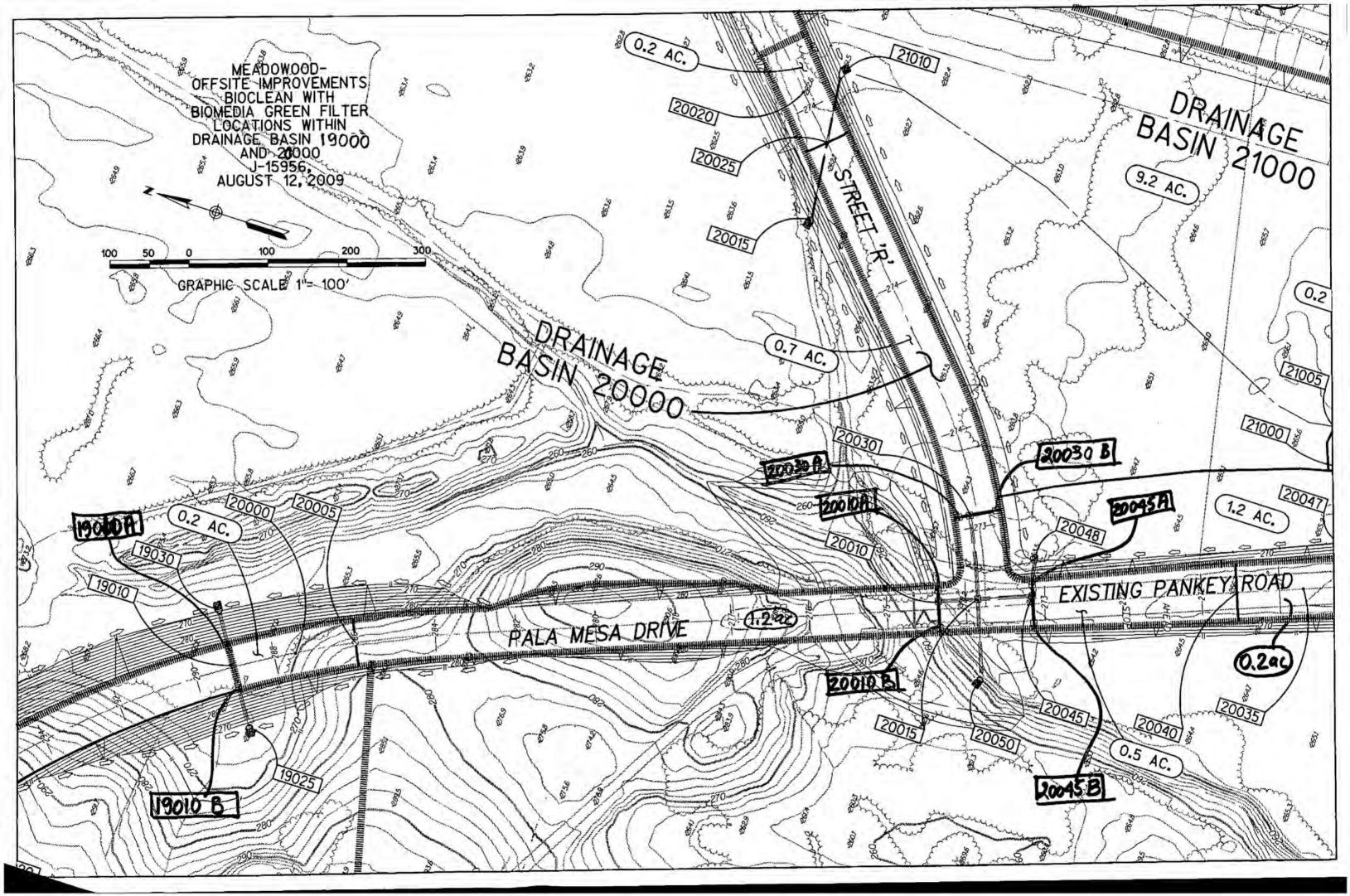












Vegetated Swales

VEGETATED SWALE SIZING CALCS FOR MEADOWOOD

Assumptions:

side slopes = 3:1 (H:V)
Mannings N = 0.25 (Water Quality)
Water Quality Depth <= 4 inches (0.33 ft)
Freeboard = 6 inches (.5 ft)

Swale	Drainage Area (acres)		Q ₁₀₀ (cfs) ²	Q _{wQ} (cfs)	Actual Slope	Bottom ³ Width, ft. (Calc)	Top⁴ Width, ft. (Calc)	WQ Depth, ft. (Calc)	Design Depth, ft. (Calc)	WQ Velocity, fps (Calc)	Design Velocity, fps (Calc)	Length⁵, ft. (Calc)	Actual Length, ft.
Swale1 (Proposed)	1.70	0.645	10.4	0.22	0.5	3.0	11.3	0.33	0.88	0.17	2.09	102	700
Swale2 (Existing)	1.50	0.49	7.0	0.15	0.5	2.0	9.9	0.32	0.82	0.16	1.91	96	200

ft = feet WQ = Water Quality cfs = cubic feet per second

- 1) Runoff Coefficient obtained from Rational Method Analysis
- 2) Q₁₀₀ was obtained utilizing an intensity of 9.5 in/hr based on 5 minute Time of Concentration and 3.6 in 6-hour precipitation
- 3) Existing Bottom width is 0.6 m (1.97 ft)
- 4) Assumes 6 inches of freeboard
- 5) Assumed 10 minutes of Residence

Meadowood J-15956 Swale Sizing for Basin 9000 Swales Associated with SR-76

Swale 1 Water Quality
NORMAL DEPTH FOR TRAPEZOIDAL CHANNELS

,	CHANNEL 1	OIDAL CHANNELS		
		0.22 CFS 3.00 FT 0.2500	SLOPE IS = SIDE SLOPE (Z1) = SIDE SLOPE (Z2) =	0.0050 FT/FT 3.00 3.00
	NORMAL DEPTH IS = VELOCITY IS = AREA IS = HYDRAULIC RADIUS = WETTED PERIMETER =	0.17 FPS 1.30 SQ FT 0.26 FT 5.06 FT	VELOCITY HEAD IS = CRITICAL DEPTH = CRITICAL VELOCITY = TOP WIDTH FOR	0.00 FT 0.05 FT 1.29 FPS
	TOP WIDTH IS = Swale 1 Flood Control NORMAL DEPTH FOR TRAPEZO CHANNEL 1		CRITICAL DEPTH =	3.32 FI
	DISCHARGE IS = BOTTOM WIDTH IS = MANNING'S N =		SIDE SLOPE (Z1) =	0.0050 FT/FT 3.00 3.00
	NORMAL DEPTH IS = VELOCITY IS = AREA IS = HYDRAULIC RADIUS = WETTED PERIMETER = TOP WIDTH IS =	2.09 FPS 4.98 SQ FT 0.58 FT 8.58 FT	VELOCITY HEAD IS = CRITICAL DEPTH = CRITICAL VELOCITY = TOP WIDTH FOR	0.07 FT 0.59 FT 3.72 FPS
	Swale 2 Water Quality NORMAL DEPTH FOR TRAPEZO CHANNEL 1	OIDAL CHANNELS	,	
	DISCHARGE IS = BOTTOM WIDTH IS = MANNING'S N =	1.97 FT		0.0050 FT/FT 3.00 3.00
	NORMAL DEPTH IS = VELOCITY IS = AREA IS = HYDRAULIC RADIUS = WETTED PERIMETER = TOP WIDTH IS =	0.16 FPS 0.94 SQ FT 0.23 FT 3.99 FT	VELOCITY HEAD IS = CRITICAL DEPTH = CRITICAL VELOCITY = TOP WIDTH FOR	0.00 FT 0.05 FT 1.28 FPS
	Swale 2 Flood Control NORMAL DEPTH FOR TRAPEZ CHANNEL 1	OIDAL CHANNELS		
	DISCHARGE IS = BOTTOM WIDTH IS = MANNING'S N =	1.97 FT	SIDE SLOPE (Z1) =	3.00
	NORMAL DEPTH IS =	0.82 FT	FROUDE NUMBER IS =	0.46

VELOCITY IS =	1.91	FPS	VELOCITY HEAD IS =	0.06 FT
AREA IS =	3.66	SQ FT	CRITICAL DEPTH =	0.55 FT
HYDRAULIC RADIUS =	0.51	FT	CRITICAL VELOCITY =	3.49 FPS
WETTED PERIMETER =	7.18	FT	· TOP WIDTH FOR	
TOP WIDTH IS =	6.91	FT	CRITICAL DEPTH =	5.28 FT

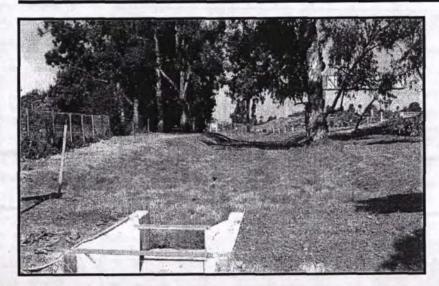
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Design Considerations

- Tributary Area
- Area Required
- Slope
- Water Availability

Description

Vegetated swales are open, shallow channels with vegetation covering the side slopes and bottom that collect and slowly convey runoff flow to downstream discharge points. They are designed to treat runoff through filtering by the vegetation in the channel, filtering through a subsoil matrix, and/or infiltration into the underlying soils. Swales can be natural or manmade. They trap particulate pollutants (suspended solids and trace metals), promote infiltration, and reduce the flow velocity of stormwater runoff. Vegetated swales can serve as part of a stormwater drainage system and can replace curbs, gutters and storm sewer systems.

California Experience

Caltrans constructed and monitored six vegetated swales in southern California. These swales were generally effective in reducing the volume and mass of pollutants in runoff. Even in the areas where the annual rainfall was only about 10 inches/yr, the vegetation did not require additional irrigation. One factor that strongly affected performance was the presence of large numbers of gophers at most of the sites. The gophers created earthen mounds, destroyed vegetation, and generally reduced the effectiveness of the controls for TSS reduction.

Advantages

 If properly designed, vegetated, and operated, swales can serve as an aesthetic, potentially inexpensive urban development or roadway drainage conveyance measure with significant collateral water quality benefits.

Targeted Constituents

\square	Sediment	
$\overline{\mathbf{V}}$	Nutrients	
$\overline{\mathbf{V}}$	Trash	
$ \nabla$	Metals	•
V	Bacteria	•
$ \nabla$	Oil and Grease	•
V	Organics	
I en	end (Removal Effectiveness)	

● Low ■ High

▲ Medium



 Roadside ditches should be regarded as significant potential swale/buffer strip sites and should be utilized for this purpose whenever possible.

Limitations

- Can be difficult to avoid channelization.
- May not be appropriate for industrial sites or locations where spills may occur
- Grassed swales cannot treat a very large drainage area. Large areas may be divided and treated using multiple swales.
- A thick vegetative cover is needed for these practices to function properly.
- They are impractical in areas with steep topography.
- They are not effective and may even erode when flow velocities are high, if the grass cover is not properly maintained.
- In some places, their use is restricted by law: many local municipalities require curb and gutter systems in residential areas.
- Swales are mores susceptible to failure if not properly maintained than other treatment BMPs.

Design and Sizing Guidelines

- Flow rate based design determined by local requirements or sized so that 85% of the annual runoff volume is discharged at less than the design rainfall intensity.
- Swale should be designed so that the water level does not exceed 2/3rds the height of the grass or 4 inches, which ever is less, at the design treatment rate.
- Longitudinal slopes should not exceed 2.5%
- Trapezoidal channels are normally recommended but other configurations, such as parabolic, can also provide substantial water quality improvement and may be easier to mow than designs with sharp breaks in slope.
- Swales constructed in cut are preferred, or in fill areas that are far enough from an adjacent slope to minimize the potential for gopher damage. Do not use side slopes constructed of fill, which are prone to structural damage by gophers and other burrowing animals.
- A diverse selection of low growing, plants that thrive under the specific site, climatic, and watering conditions should be specified. Vegetation whose growing season corresponds to the wet season are preferred. Drought tolerant vegetation should be considered especially for swales that are not part of a regularly irrigated landscaped area.
- The width of the swale should be determined using Manning's Equation using a value of 0.25 for Manning's n.

Construction/Inspection Considerations

- Include directions in the specifications for use of appropriate fertilizer and soil amendments based on soil properties determined through testing and compared to the needs of the vegetation requirements.
- Install swales at the time of the year when there is a reasonable chance of successful
 establishment without irrigation; however, it is recognized that rainfall in a given year may
 not be sufficient and temporary irrigation may be used.
- If sod tiles must be used, they should be placed so that there are no gaps between the tiles;
 stagger the ends of the tiles to prevent the formation of channels along the swale or strip.
- Use a roller on the sod to ensure that no air pockets form between the sod and the soil.
- Where seeds are used, erosion controls will be necessary to protect seeds for at least 75 days after the first rainfall of the season.

Performance

The literature suggests that vegetated swales represent a practical and potentially effective technique for controlling urban runoff quality. While limited quantitative performance data exists for vegetated swales, it is known that check dams, slight slopes, permeable soils, dense grass cover, increased contact time, and small storm events all contribute to successful pollutant removal by the swale system. Factors decreasing the effectiveness of swales include compacted soils, short runoff contact time, large storm events, frozen ground, short grass heights, steep slopes, and high runoff velocities and discharge rates.

Conventional vegetated swale designs have achieved mixed results in removing particulate pollutants. A study performed by the Nationwide Urban Runoff Program (NURP) monitored three grass swales in the Washington, D.C., area and found no significant improvement in urban runoff quality for the pollutants analyzed. However, the weak performance of these swales was attributed to the high flow velocities in the swales, soil compaction, steep slopes, and short grass height.

Another project in Durham, NC, monitored the performance of a carefully designed artificial swale that received runoff from a commercial parking lot. The project tracked 11 storms and concluded that particulate concentrations of heavy metals (Cu, Pb, Zn, and Cd) were reduced by approximately 50 percent. However, the swale proved largely ineffective for removing soluble nutrients.

The effectiveness of vegetated swales can be enhanced by adding check dams at approximately 17 meter (50 foot) increments along their length (See Figure 1). These dams maximize the retention time within the swale, decrease flow velocities, and promote particulate settling. Finally, the incorporation of vegetated filter strips parallel to the top of the channel banks can help to treat sheet flows entering the swale.

Only 9 studies have been conducted on all grassed channels designed for water quality (Table 1). The data suggest relatively high removal rates for some pollutants, but negative removals for some bacteria, and fair performance for phosphorus.

Removal Efficiencies (% Removal)											
Study	TSS	TP	TN	NO ₃	Metals	Bacteria	Туре				
Caltrans 2002	77	8	67	66	83-90	-33	dry swales				
Goldberg 1993	67.8	4.5	-	31.4	42-62	-100	grassed channel				
Seattle Metro and Washington Department of Ecology 1992	60	45		-25	2-16	-25	grassed channel				
Seattle Metro and Washington Department of Ecology, 1992	83	29	-	-25	46-73	-25	grassed channel				
Wang et al., 1981	80	-	-	-	70-80	-	dry swale				
Dorman et al., 1989	98	18	-	45	37-81	-	dry swale				
Harper, 1988	87	83	84	80	88-90	-	dry swale				
Kercher et al., 1983	99	99	99	99	99		dry swale				
Harper, 1988.	81	17	40	52	37-69	-	wet swale				
Koon, 1995	67	39	-	9.	-35 to 6	-	wet swale				

While it is difficult to distinguish between different designs based on the small amount of available data, grassed channels generally have poorer removal rates than wet and dry swales, although some swales appear to export soluble phosphorus (Harper, 1988; Koon, 1995). It is not clear why swales export bacteria. One explanation is that bacteria thrive in the warm swale soils.

Siting Criteria

The suitability of a swale at a site will depend on land use, size of the area serviced, soil type, slope, imperviousness of the contributing watershed, and dimensions and slope of the swale system (Schueler et al., 1992). In general, swales can be used to serve areas of less than 10 acres, with slopes no greater than 5 %. Use of natural topographic lows is encouraged and natural drainage courses should be regarded as significant local resources to be kept in use (Young et al., 1996).

Selection Criteria (NCTCOG, 1993)

- Comparable performance to wet basins
- Limited to treating a few acres
- Availability of water during dry periods to maintain vegetation
- Sufficient available land area

Research in the Austin area indicates that vegetated controls are effective at removing pollutants even when dormant. Therefore, irrigation is not required to maintain growth during dry periods, but may be necessary only to prevent the vegetation from dying.

The topography of the site should permit the design of a channel with appropriate slope and cross-sectional area. Site topography may also dictate a need for additional structural controls. Recommendations for longitudinal slopes range between 2 and 6 percent. Flatter slopes can be used, if sufficient to provide adequate conveyance. Steep slopes increase flow velocity, decrease detention time, and may require energy dissipating and grade check. Steep slopes also can be managed using a series of check dams to terrace the swale and reduce the slope to within acceptable limits. The use of check dams with swales also promotes infiltration.

Additional Design Guidelines

Most of the design guidelines adopted for swale design specify a minimum hydraulic residence time of 9 minutes. This criterion is based on the results of a single study conducted in Seattle, Washington (Seattle Metro and Washington Department of Ecology, 1992), and is not well supported. Analysis of the data collected in that study indicates that pollutant removal at a residence time of 5 minutes was not significantly different, although there is more variability in that data. Therefore, additional research in the design criteria for swales is needed. Substantial pollutant removal has also been observed for vegetated controls designed solely for conveyance (Barrett et al, 1998); consequently, some flexibility in the design is warranted.

Many design guidelines recommend that grass be frequently mowed to maintain dense coverage near the ground surface. Recent research (Colwell et al., 2000) has shown mowing frequency or grass height has little or no effect on pollutant removal.

Summary of Design Recommendations

- The swale should have a length that provides a minimum hydraulic residence time of at least 10 minutes. The maximum bottom width should not exceed 10 feet unless a dividing berm is provided. The depth of flow should not exceed 2/3rds the height of the grass at the peak of the water quality design storm intensity. The channel slope should not exceed 2.5%.
- A design grass height of 6 inches is recommended.
- 3) Regardless of the recommended detention time, the swale should be not less than 100 feet in length.
- 4) The width of the swale should be determined using Manning's Equation, at the peak of the design storm, using a Manning's n of 0.25.
- 5) The swale can be sized as both a treatment facility for the design storm and as a conveyance system to pass the peak hydraulic flows of the 100-year storm if it is located "on-line." The side slopes should be no steeper than 3:1 (H:V).
- 6) Roadside ditches should be regarded as significant potential swale/buffer strip sites and should be utilized for this purpose whenever possible. If flow is to be introduced through curb cuts, place pavement slightly above the elevation of the vegetated areas. Curb cuts should be at least 12 inches wide to prevent clogging.
- Swales must be vegetated in order to provide adequate treatment of runoff. It is important to maximize water contact with vegetation and the soil surface. For general purposes, select fine, close-growing, water-resistant grasses. If possible, divert runoff (other than necessary irrigation) during the period of vegetation

establishment. Where runoff diversion is not possible, cover graded and seeded areas with suitable erosion control materials.

Maintenance

The useful life of a vegetated swale system is directly proportional to its maintenance frequency. If properly designed and regularly maintained, vegetated swales can last indefinitely. The maintenance objectives for vegetated swale systems include keeping up the hydraulic and removal efficiency of the channel and maintaining a dense, healthy grass cover.

Maintenance activities should include periodic mowing (with grass never cut shorter than the design flow depth), weed control, watering during drought conditions, reseeding of bare areas, and clearing of debris and blockages. Cuttings should be removed from the channel and disposed in a local composting facility. Accumulated sediment should also be removed manually to avoid concentrated flows in the swale. The application of fertilizers and pesticides should be minimal.

Another aspect of a good maintenance plan is repairing damaged areas within a channel. For example, if the channel develops ruts or holes, it should be repaired utilizing a suitable soil that is properly tamped and seeded. The grass cover should be thick; if it is not, reseed as necessary. Any standing water removed during the maintenance operation must be disposed to a sanitary sewer at an approved discharge location. Residuals (e.g., silt, grass cuttings) must be disposed in accordance with local or State requirements. Maintenance of grassed swales mostly involves maintenance of the grass or wetland plant cover. Typical maintenance activities are summarized below:

- Inspect swales at least twice annually for erosion, damage to vegetation, and sediment and debris accumulation preferably at the end of the wet season to schedule summer maintenance and before major fall runoff to be sure the swale is ready for winter. However, additional inspection after periods of heavy runoff is desirable. The swale should be checked for debris and litter, and areas of sediment accumulation.
- Grass height and mowing frequency may not have a large impact on pollutant removal.
 Consequently, mowing may only be necessary once or twice a year for safety or aesthetics or to suppress weeds and woody vegetation.
- Trash tends to accumulate in swale areas, particularly along highways. The need for litter removal is determined through periodic inspection, but litter should always be removed prior to moving.
- Sediment accumulating near culverts and in channels should be removed when it builds up to 75 mm (3 in.) at any spot, or covers vegetation.
- Regularly inspect swales for pools of standing water. Swales can become a nuisance due to
 mosquito breeding in standing water if obstructions develop (e.g. debris accumulation,
 invasive vegetation) and/or if proper drainage slopes are not implemented and maintained.

Cost

Construction Cost

Little data is available to estimate the difference in cost between various swale designs. One study (SWRPC, 1991) estimated the construction cost of grassed channels at approximately \$0.25 per ft². This price does not include design costs or contingencies. Brown and Schueler (1997) estimate these costs at approximately 32 percent of construction costs for most stormwater management practices. For swales, however, these costs would probably be significantly higher since the construction costs are so low compared with other practices. A more realistic estimate would be a total cost of approximately \$0.50 per ft², which compares favorably with other stormwater management practices.

Table 2 Swale Cost Estimate (SEWRPC, 1991)

				Unit Cost			Total Cost	
Component	Unit	Extent	Low	Moderate	High	Low	Moderate	High
Mobilization / Demobilization-Light	Swale	1	\$107	5274	\$441	\$107	\$274	\$441
Site Preparation Clearings	Acrie Acre Yd³ Yd²	0.5 0.25 372 1,210	\$2,200 \$3,800 \$2.10 \$0.20	\$3,800 \$5,200 \$3.70 \$0.35	\$5,400 \$8,600 \$5.30 \$0.50	\$1,100 \$950 \$781 \$242	\$1,900 \$1,300 \$1,376 \$424	\$2,700 \$1,850 \$1,972 \$605
Sites Development Salvaged Topsoil Seed, and Mulch' Sod ⁹	Yd ²	1,210 1,210	\$0.40 \$1.20	\$1.00 \$2.40	\$1.60 \$3.60	\$484 \$1,452	\$1,210 \$2,904	\$1,936 \$4,356
Subtotal		-		-		\$5,116	\$9,388	\$13,660
Contingencies	Swale	1	25%	25%	25%	\$1,279	\$2,347	\$3,415
Total						\$6,395	\$11,735	\$17,075

Source: (SEWRPC, 1991)

Note: Mobilization/demobilization refers to the organization and planning involved in establishing a vegetative swale.

[&]quot;Swale has a bottom width of 1.0 foot, a top width of 10 feet with 1:3 side slopes, and a 1,000-foot length.

Area cleared = (top width + 10 feet) x swale length.

^c Area grubbed = (top width x swale length).

⁴Volume excavated = (0.67 x top width x swale depth) x swale length (parabolic cross-section).

Area titled = (top width + 8(swale depth²) x swale length (parabolic cross-section).
3(top width)

Area seeded = area cleared x 0.5.

Area sodded = area cleared x 0.5.

Estimated Maintenance Costs (SEWRPC, 1991)

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Maintenance Cost

Caltrans (2002) estimated the expected annual maintenance cost for a swale with a tributary area of approximately 2 ha at approximately \$2,700. Since almost all maintenance consists of mowing, the cost is fundamentally a function of the mowing frequency. Unit costs developed by SEWRPC are shown in Table 3. In many cases vegetated channels would be used to convey runoff and would require periodic mowing as well, so there may be little additional cost for the water quality component. Since essentially all the activities are related to vegetation management, no special training is required for maintenance personnel.

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